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SOLAR FLAT PLATE

FINAL REPORT

HIT-206

October 1966

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FOREWORD

The analysis and computer program described herein was prepared under Contract Number NAS5-9167 for the National Aeronautics and Space Administration, Goddard Space Flight Center.

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SUMMARY

Solar thermoelectric energy conversion panels may be constructed from modules, each of which consists of an absorber, a thermoelement or thermoelectric couple, and a radiator. The absorber collects solar heat which causes a high temperature to be established. The thermoelements convert a portion of this heat to electricity, and the unconverted heat is rejected to space by the radiator.

Analyses conducted prior to the work reported herein have been limited to mathematical models which could be handled using manual calculation techniques. Calculation accuracy has consequently not been as precise as desired. Therefore, an accurate analysis has been developed, reported herein, so that the performance characteristics of the solar flat plate may be predicted for expected operational conditions. The mathematical model obtained as a result of this study contains a number of non-linear second order differential equations which cannot be solved analytically. A digital computer program therefore has been written for the IBM-7094 so that a solution may be obtained.

Major emphasis has been placed in the writing of the program so that calculation accuracy and ease of use of the program will result. The calculation accuracy has been obtained through a careful selection of the assumptions necessary to define the mathematical model and by careful computation techniques. Ease of use has been obtained through the use of the simplified input routines and carefully presented data. The input routine which has been developed for this program is virtually independent of format and the required data may be read in almost any order. Parametric studies may be performed by reading data which have been changed from previous runs while data which have not been changed need not be reread. Automatic generation of all of the mesh information is taken care of by the computer program with an input definition of the number of points around the periphery of the solar flat plate module. Computer output options exist so that limited or detailed computed results may be obtained. If desired, the output may contain a map of the computer node points printed to a scale of one part in 100, as well as temperatures and electrical characteristics as functions of time.

A comparison of the computer program results with experimental and manual calculations has been obtained. These show good correlation with the limited experimental information which is available, and predict slightly lower performance characteristics than have been obtained using manual approaches. In general, the correlation is good.

A limited parametric study has been performed and reported herein which shows characteristics to be expected for earth orbit behavior and for an application close to the sun.

I. INTRODUCTION

A. Background

The satisfaction of auxiliary power requirements in space constitutes a difficult problem. To date, most of these requirements have been met by the direct conversion of solar radiation to electricity. Until recently, the only practical solid-state device available for this purpose was the photovoltaic cell. Recent developmental work has resulted in the availability of an alternate technique, the thermoelectric flat plate solar generator. This electrical supply has promise of more attractive cost per watt of electrical power produced, lower weight/watt of power produced, and has high resistance to nuclear radiation. The solar flat plate also appears attractive for close-in orbits to the sun where at present photovoltaic cells would be difficult to use.

The background technology and a number of preliminary calculations illustrating characteristics are discussed by Fuschillo, * and will not be considered in detail in this report. The purpose of this report is to present an investigation of the theoretical performance of the device, to compare the results of the theoretical investigation with experimentally determined performance, and to present a parametric study which may be utilized to evaluate use of the device for various postulated missions.

B. The Solar Flat Plate Thermoelectric Generator

The solar thermoelectric generator consists of three major items: an absorber, thermoelements and a radiator. The absorber consists of a thin plate coated to give a high absorptivity for solar radiation with a low emissivity. This is roughly sun-oriented and attains a relatively high temperature because of its absorption-emissive properties. This heats the hot end of the thermoelements which are attached to the back of the absorber. The other end of the thermoelement is attached to a radiator, which has an exposed surface with a high emissivity coating so that unconverted heat can be rejected to space. The internal surfaces which do not "see" space are normally highly polished to minimize radiant interchange between the absorber and radiator.

Normal practice is to construct the solar panel so that the radiator and absorber serve as electrical interconnections between the thermoelements. Any desired arrays of series or series-parallel arrangements may be immediately obtained. A photograph of a typical panel is shown in Figure I-1. Construction details may be seen in Figure I-2 which shows the components of a typical cell.

^{*} Fuschillo, N., Gibson, R., Eggelston, F. K., and Epstein, J.,
"Flat Plate Solar Electric Generator for Nuclear Earth Orbits", Advanced
Energy Conversion, Vol. 6, pp. 103-125, 1966.

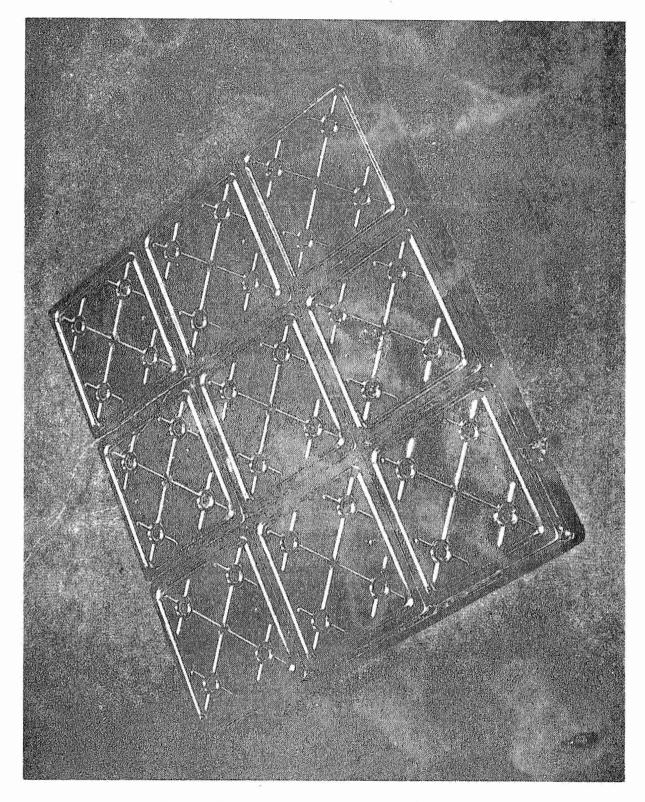


Figure I-1. Flat Plate Solar Thermoelectric Generator Panel

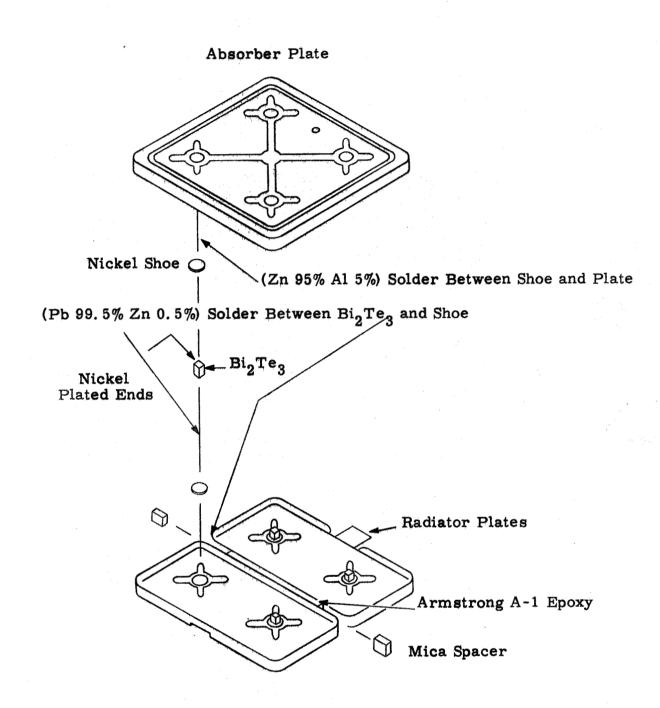


Figure I-2. Unit Couple Assembly Drawing

II. PANEL ANALYSIS

Two basic types of analyses are necessary to fully investigate the solar flat plate capabilities. Long term behavior of the type associated with a constant solar flux and constant heat rejection characteristics are of interest so that the steady state performance may be investigated. Power generation behavior associated with transient type phenomena are required for such applications as a non-oriented array mounted on a spinning satellite or to predict the characteristics when a satellite moves from shade to sun conditions or vice versa. Either of these basic investigations may be performed by considering the three components comprising the system: the thermoelements, the absorber and the radiator.

Thermoelectric theory is relatively well known from the analysis or engineering standpoint and will accurately predict behavior provided suitable mathematical models are selected. The absorber and radiator may both be described utilizing transient heat conduction theory with appropriate incorporation of the radiant heat transfer phenomena. The basic assumptions required are as follows:

- (1) The radiator and absorber may be treated as transient two-dimensional heat conductors with a variable heat source and no temperature gradient perpendicular to the surface.
- (2) Heat input to the absorber is due to the solar flux, planet albedo, and an effective planet temperature with full recognition given to the various absorptivity and view factor terms.
- (3) Radiator input is treated in a manner similar to the absorber.
- (4) Thermal coupling between the absorber and radiator occurs due to the thermoelements and radiant heat transfer between the two plates.
- (5) The thermoelement can be described by a transient one-dimensional differential equation which contains terms for heat conduction, Joule heating, the Peltier, Seebeck and Thomson effects, and radiant interchange between the thermoelement, absorber and radiator.
- (6) The effect of resistance between a thermoelement and mounting hardware is included as a "contact" resistance (which must be determined experimentally).
- (7) Heat generation within the plate due to the flow of electricity and the effect of heat received by the plate from the thermoelements is small and may be neglected.

The justification for these assumptions and the mathematical model which results are discussed in the following sections.

A. Thermoelectric Analysis

Analysis of thermoelectric elements is generally achieved by taking a heat balance over the entire thermoelectric couple to determine the heat required at the hot junction. If this is then divided into the output power, the efficiency is obtained. Suitable differentiations are then commonly used to obtain an optimum efficiency. It is relatively common practice to ignore the contact resistance in this approach, or to make assumptions pertaining to the behavior of contact resistance with cross-sectional area. If for the moment the correctness or incorrectness of these assumptions is neglected, one problem involved with this approach is the difficulty of understanding the errors involved in obtaining the heat balance. A further problem is that this approach may be used only for the steady state, and is inappropriate for use with transient analysis. One of the first analyses which considered the steady state thermoelectric behavior from a microscopic standpoint was presented by Lyon and Bustard.* Although this analysis was derived on the basis of nontransient conditions, it is a relatively simple extension to utilize it for the transient representation. The approach will be used herein because it has been shown to be accurate.

Although the assumption of Lyon and Bustard that the variation of contact resistance with the inverse of cross sectional area is good for some analyses, it is not a legitimate assumption for all cases. The error is expected to become larger as thermoelectric element size is decreased, and since size will be of importance in some of the applications of the solar flat plate, the assumption is not considered legitimate herein.

To obtain a mathematical model which describes thermoelectric behavior, we first consider the thermoelectric phenomena which are involved. These are:

- (1) Thermal conduction: the transport of heat from one position in the thermoelectric material to another due to the temperature gradient.
- (2) Joule heating: the internal heating effect within the thermoelectric material due to resistance to the flow of electricity.
- (3) Seebeck effect: the phenomenon of the flow of electricity that occurs in a closed loop which is composed of two dissimilar materials when the junction between the materials is maintained at different temperatures.
- (4) Thomson effect: the phenomenon of heat generation or absorption which takes place when an electrical current flows in the presence of a temperature gradient.

^{*} Lyon, W. C, and Bustard, T. S., "Digital Computation of Thermoelement Operational Parameters", Advanced Energy Conversion, Vol. 2, 1962, pp. 197-208.

(5) Peltier effect: the heat generation or absorption phenomenon that occurs at a junction between dissimilar materials when an electrical current is caused to flow.

Incorporation of these well understood theoretical effects is sufficient to describe the thermoelectric behavior if no other perturbations occur. However, any mathematical analysis must include the effects of the surroundings to a greater or a lesser extent and must also consider the actual physical situation in which the thermoelements are manufactured or used. Consequently, further assumptions are necessary. These are:

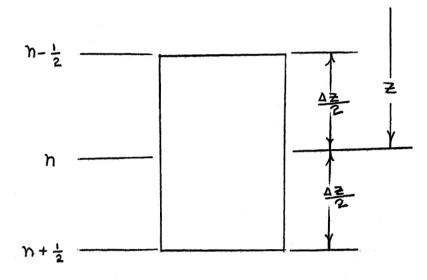
- (1) The thermoelectric material is homogeneous.
- (2) Heat interchange between the lateral or exposed surface of the thermoelements may be represented by considering only radiant heat transfer between the thermoelement surface and the surroundings as seen by the surface.
- (3) There is no temperature gradient within the thermoelement normal to the axis.

Homogeneity of material is generally obtained to the degree necessary for a valid mathematical analysis. This assumption is basically necessary at this time regardless of the degree of homogeneity or non-homogeneity in order that a mathematical representation can be obtained. However, a good thermoelectric material is homogeneous, and it is expected that little error will be involved with this assumption.

The assumption that the thermoelement exchanges heat from the exposed surface with its surroundings is in conflict with the assumption that no temperature gradient exists within the thermoelement normal to the axis. Obviously, if heat is going to be rejected from the lateral surface, there must be a gradient with respect to a normal drawn to that surface. This assumption is justified, however, because the quantity of heat which is conducted along the thermoelement is very much greater than that which is radiantly interchanged between the thermoelement and the absorber-radiator. The error involved is consequently small.

The calculation of the energy interchange between the thermoelement surface and its surroundings could become extremely complicated, with a consequent result that a tremendous amount of time would be used in obtaining numerical results. However, the thermoelement basically "sees" only the absorber and the radiator inside surfaces. If these are assumed to be represented by average temperatures, then an approximation of the heat transfer may be readily obtained. This approximation will not significantly perturb the results because it may be readily shown that the heat transfer from the surfaces is small in comparison to that which is conducted. This assumption therefore will be incorporated into the analysis since it will not affect the results.

Now consider a small section of thermoelement:



The following energy balance will describe the section behavior:

The rate at which heat flows into the section is:

-k (t)_{n-1/2} A (
$$\frac{\partial}{\partial} \frac{T}{Z} \frac{(t)}{n-1/2}$$
) (II-2)

where it is assumed that there is no capacitance or impedance effect, and;

k = thermal conductivity

t = time

A = cross sectional area normal to the temperature gradient

T = temperature

Z = position

The rate at which heat flows out of the section is:

-k (t)_{n + 1/2} A (
$$\frac{\partial T(t)}{\partial Z}$$
)_{n + 1/2} (II-3)

The rate of heat generation is:

$$\left[I(t)\right]^{2} R(t)_{n} + \gamma(t)_{n} I(t) \left(\frac{\int T(t)}{\partial Z}\right)_{n} \Delta Z \qquad (II-4)$$

where:

I = electrical current

R = electrical resistance of the nth segment

Υ = Thomson coefficient

and the first term represents the Joule heating, the second the Thomson effect.

A fictitious heat generation term can be used to represent the heat interchange between the thermoelement and its "surroundings". This term is:

- F(t) P
$$\triangle Z$$
 $\left[T \left(t \right)_{n}^{4} - \overline{T_{s} \left(t \right)^{4}} \right]$ (II-5)

where:

F = view factor

P = perimeter of thermoelement measured on a plane normal to the Z-axis

T_s⁴ = surrounding temperature to the fourth power averaged

The rate of heat accumulation is:

$$C_{p}(t)_{n} P(t)_{n} A \Delta Z \frac{\partial T(t)_{n}}{\partial t}$$
(II-6)

where:

C_p = heat capacity C = density

Substituting these into Equation (II-1) yields:

$$-k (t)_{n-1/2} A \left(\frac{\partial T(t)}{\partial Z} \right)_{n-1/2} + k (t)_{n+1/2} A \left(\frac{\partial T(t)}{\partial Z} \right)_{n+1/2} +$$

$$+ \left[I(t) \right]^{2} R (t)_{n} + \gamma (t)_{n} I(t) \left(\frac{\partial T(t)}{\partial Z} \right)_{n} \Delta Z -$$

$$- F(t) P \Delta Z \left[T(t)_{n}^{4} - \overline{T_{s}(t)^{4}} \right] = C_{p} (t)_{n} \rho (t)_{n} A \Delta Z \frac{\partial T(t)_{n}}{\partial Z} (II-7)$$

The internal electrical resistance can be written:

$$R(t)_{n} = \frac{P(t)_{n} \Delta Z}{A}$$
 (II-8)

where \mathcal{L} = electrical resistivity. Substituting this and taking the limit as Δ Z approaches zero results in:

$$\frac{\partial}{\partial Z} \left[k \left(Z, t \right) \frac{\partial}{\partial Z} \frac{T \left(Z, t \right)}{\partial Z} \right] + \frac{\mathbf{f} \left(Z, t \right) \left[I \left(t \right) \right]^{2}}{A^{2}} - \frac{F \left(t \right) P}{A}$$

$$\left[T \left(Z, t \right)^{4} - \overline{T_{S} \left(t \right)^{4}} \right] + \left(\frac{\Upsilon \left(Z, t \right) I \left(t \right)}{A} \right) \frac{\partial}{\partial Z} \frac{T \left(Z, t \right)}{Z} =$$

$$= C_{p} \left(Z, t \right) P \left(Z, t \right) \frac{\partial}{\partial Z} \frac{T \left(Z, t \right)}{Z} \qquad (II-9)$$

The physical properties are actually known as functions of T(Z, t). Further, the Thomson coefficient can be expressed as:

where \triangleleft = Seebeck coefficient.

Making use of these, the differential equation becomes:

$$\frac{\partial}{\partial Z} \left[k (T) \frac{\partial}{\partial Z} T (Z, t) \right] + \frac{f'(T) \left[I (t) \right]^{2}}{A^{2}} - \frac{F (t) P}{A} \left[T (Z, t)^{4} - \overline{T_{s}(t)^{4}} \right] - \left[\frac{T (Z, T) I (t)}{A} \right] \frac{\partial \alpha (T)}{\partial Z} =$$

$$= C_{p} (T) P (T) \frac{\partial T (Z, t)}{\partial t}$$
 (II-11)

where the subscripts on the T have been left out if T is used as a subscript, but it should be realized that the variation still exists.

There is little chance of solving Equation (II-11) in a useful analytic manner, so we re-write it in the difference form:

$$\begin{bmatrix} k & (T) & \frac{\partial T & (t)}{\partial Z} \end{bmatrix}_{n+1/2} - \begin{bmatrix} k & (t) & \frac{\partial T & (t)}{\partial Z} \end{bmatrix}_{n-1/2} + \\
+ \frac{f'(t)_n \left[I & (t) \right]^2 \Delta Z}{A^2} - \frac{T & (t)_n I & (t)}{A} \begin{bmatrix} \alpha & (t)_{n+1/2} - \\ \alpha & (t)_{n-1/2} \end{bmatrix} - \frac{F & (t) P}{A} \begin{bmatrix} T & (t)_n^4 - \overline{T_s} & (t)^4 \end{bmatrix} = \\
= C_p & (t)_n P & (t)_n \frac{d T & (t)_n \Delta Z}{dt} \tag{II-12}$$

$$k (t)_{n+1/2} \left[\frac{T(t)_{n+1} - T(t)_{n}}{\Delta Z} \right] - k (t)_{n-1/2} \left[\frac{T(t)_{n} - T(t)_{n-1}}{\Delta Z} \right] + \frac{P(t)_{n} \left[I(t) \right]^{2} \Delta Z}{A^{2}} - \frac{T(t)_{n} I(t)}{A} \left[\propto (t)_{n+1/2} - \propto (t)_{n-1/2} \right] - \frac{F(t) P}{A} \left[T(t)_{n}^{4} - T_{s}(t)^{4} \right] = C_{p}(t)_{n} P(t)_{n} \frac{d T(t)_{n} \Delta Z}{dt}$$
 (II-13)

In general:

$$\int_{n+1/2} \approx \frac{\int_{n+1}^{+} \int_{n}^{+}}{2}$$
 (II-14)

where \mathfrak{r} is some property, so that:

$$\frac{\left[k \left(t \right)_{n+1} + k \left(t \right)_{n} \right] \left[T \left(t \right)_{n+1} - T \left(t \right)_{n} \right]}{2 \Delta Z} - \frac{\left[k \left(t \right)_{n} + k \left(t \right)_{n-1} \right] \left[T \left(t \right)_{n} - T \left(t \right)_{n-1} \right]}{2 \Delta Z} + \frac{\mathbf{P} \left(t \right)_{n} \left[I \left(t \right) \right]^{2} \Delta Z}{A^{2}} - \frac{T \left(t \right)_{n} I \left(t \right)}{2 A} \left[\mathbf{A}^{2} \left(t \right)_{n+1} - \mathbf{A}^{2} \left(t \right)_{n-1} \right] - \frac{\mathbf{F} \left(t \right) \mathbf{P}}{A} \left[T \left(t \right)_{n}^{4} - T_{s} \left(t \right)^{4} \right] = C_{p} \left(t \right)_{n} \mathbf{P} \left(t \right)_{n} \frac{\mathbf{A}^{2}}{\mathbf{A}^{2}} \qquad (II-15)$$

which can be rewritten as:

$$T_{n, j+1} = T_{n, j} + \frac{\Delta t}{C_{pn, j} \rho_{n, j} \Delta Z} \left\{ \frac{k_{n+1, j} + k_{n, j}}{2 \Delta Z} \right\}$$

$$\left[T_{n+1, j} - T_{n, j} \right] - \frac{k_{n, j} + k_{n-1, j}}{2 \Delta Z} \left[T_{n, j} - T_{n-1, j} \right] + \frac{\rho_{n, j} I_{j}^{2} \Delta Z}{A^{2}} - \frac{T_{n, j} I_{j}}{2 A} \left[\alpha_{n+1, j} - \alpha_{n-1, j} \right] - \frac{F_{j} P}{A} \left[T_{n, j} - T_{s, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{j} P}{A^{2}} \left[T_{n, j} - \alpha_{n-1, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

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$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{n+1, j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{n+1, j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{n+1, j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{n+1, j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

$$\left[T_{n+1, j} - \alpha_{n-1, j} \right] - \frac{\Gamma_{n+1, j} P}{A^{2}} \left[T_{n+1, j} - \alpha_{n-1, j} \right]$$

where the time derivative has been changed to a forward finite difference approximation, indicated by the j subscript. Note that the only j+1 term is on the left side of the equation, which greatly simplifies calculations.

This equation describes the thermoelectric performance within the thermoelement but is not applicable to the node at each end. Minor modifications allow this equation to also be applied at the end nodes. For example, at the hot end the n - 1 node is meaningless. However, the temperature represented by the n - 1 node may be represented approximately by the adjoining node in the absorber to which the thermoelement is attached. The Seebeck coefficient for the n-1 node may be treated as the Seebeck coefficient for the nth node for this one point. This introduces negligible error because the boundary condition represented by the Peltier cooling is introduced separately as will be explained later. One of the thermal conductivity terms must also

be eliminated in a similar manner. This introduces very small error in the result since essentially a numberical average is being obtained. The same type of changes can be made at the other end of the thermoelement where it contacts the radiator. In this case, the n+1 node is meaningless, and is treated in a similar way.

The portion of the radiator and of the absorber which contacts the ends of the thermoelement is assumed to be a uniform temperature region with respect to position. This assumption is consistent with the previously stated assumption that there is no temperature gradient in a plane perpendicular to the thermoelement axis. It introduces only a very small error in the results because the volume involved is small and the temperature gradients over such a small volume will be minimal. The boundary conditions between the absorber and the thermoelement or between the radiator and the thermoelement are introduced during the treatment of this node. The rate at which heat is removed from the portion of the absorber in contact with the thermoelement can be described by:

$$Q_{i}(t) = -k(t)_{1} A \left[\frac{\partial T(Z, t)}{\partial Z} \right]_{Z = 0} +$$

$$+ \propto (t)_{1} I(t) T(t)_{1} - \left[I(t) \right]^{2} R_{ci}(t)$$
(II-17)

where the first term is the heat conducted away by the thermoelement, the second is the Peltier cooling, the third is the Joule heating term at the contact, and:

Q_i = heat flow into thermoelement R_{oi} = contact resistance at the hot end

The subscript one refers to the first node in the thermoelement (the hot end). The heat flow rate out of the cold end is:

$$Q_{o}(t) = -k(t)_{N} A \left[\frac{\partial T(Z, t)}{\partial Z} \right]_{Z=Z} +$$

$$+ < (t)_{N} I (t) T (t)_{N} + [I (t)]^{2} R_{co} (t)$$
 (II-18)

where the subscripts N and o refer to the heat out (cold) end and $0 \le Z \le Z$.

The derivative portions of these equations represent the change of temperature with respect to position within the thermoelement as the thermoelement end is approached from the inside. These terms may be immediately written in difference form and can therefore be readily evaluated using the previously presented difference equations. It is assumed that the contact resistances are known as functions of temperature from experimental data. Since the equations can be used to compute temperature, the contact resistances then can also be computed. The same is true of the other terms which appear in these equations. Again, the attractiveness of a forward difference technique is apparent because it is not necessary to iterate each time during the computation process. Were some other difference technique to be used, either iterative techniques or complicated approaches would be required which could be more time consuming. (The numerical approach will be expanded in later sections.)

The previously described equations are sufficient to enable thermoelectric performance to be calculated provided the electrical characteristics have been determined. However, the electrical characteristics depend upon the thermoelement temperatures and behavior. Consequently, these characteristics must be incorporated into the analysis so that a simultaneous solution may be obtained. To accomplsih this, we first consider the following equation which gives the total internal resistance of a thermoelement:

$$R_{i}(t) = \int_{\Omega} \frac{Z_{i}(z_{s} t)}{A} dz$$
 (II-19)

The open circuit voltage is:

errout voltage 1s:
$$\begin{array}{cccc}
\text{(II-20)} \\
\text{(II-20)} \\
\text{(II-20)}
\end{array}$$

These two equations represent the behavior for a single thermoelement. In practice, the indicated operations will be performed for an N element and a P element, and the resistances and the voltages will then be added to obtain the behavior for a complete couple. Multiplication of these results by the number of couples immediately yields the overall characteristics of the complete system. The following equation immediately results from incorporating these answers into an analysis of the system circuit including a load resistance:

$$e_{N}(t) + e_{P}(t) - I(t) \left[\frac{R_{e}(t)}{M} + R_{t}(t) \right] = 0$$
 (II-21)

where:

N refers to the negative element

P refers to the positive element

M = number of couples

R = external or load resistance

R₊ = total internal resistance per couple

=
$$R_{iN}$$
 (t) + R_{iP} (t) + R_{CCN} (t) + R_{CCP} (t) + R_{CHN} (t) + R_{CHP} (t)

R_{CC} = cold end contact resistance (including radiator)

R_{CH} = hot end contact resistance (including absorber)

The output power is now:

$$P(t) = I(t)^{2} R_{e}(t)$$
 (II-22)

The efficiency of the system can be defined in two ways:

$$\eta = \frac{\text{power delivered by thermoelement}}{\text{heat absorbed by thermoelement}} = \frac{\text{thermoelectric}}{\text{efficiency}}$$
(II-23)

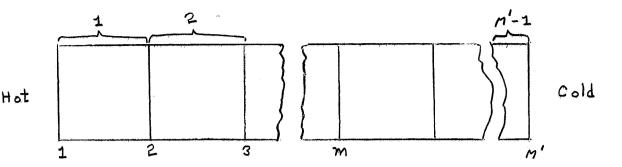
$$\eta = \frac{\text{useful power delivered to load}}{\text{heat incident on absorber}} = \frac{\text{overall}}{\text{efficiency}}$$
(II-24)

It is interesting to note that the latter expression will become infinite when the solar heat is cut off, but the generator continues to function for a short time because of stored thermal energy.

To obtain a mean efficiency for any particular situation, it is only necessary to integrate over the time span of interest.

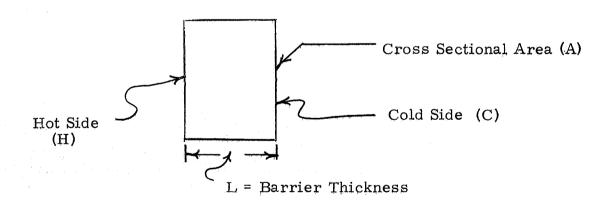
The same technique can be extended to a segmented thermoelement. However, it is necessary to include the effects of the discontinuity between the segments. These effects include contact resistances, inert material caused temperature drops, barrier losses, etc. Practical considerations of this type could cause an actual loss in switching to a segmented system as compared to a predicted gain for an ideal situation.

To gain further insight into the behavior of segmented systems, consider the following thermoelement leg:



The heat absorbed by this element at the hot end can be obtained by applying Equation (II-17) at this point. The heat given up at the cold end of segment 1 can be immediately determined by using Equation (II-18). The behavior within segment 1 is described by Equation (II-16). The same statements can be made for each of the M' - 1 segments of which the thermoelement is composed.

The use of Equations (II-17) and (II-18) automatically includes the effect of contact resistance between the segments. In reality, a temperature drop could occur in a barrier material between the segments. Since this material will bethin, its behavior can be described by considering:



The rate of heat flow entering the hot side is the heat given up by the thermoelement to the left. The heat flow rate out is that absorbed by the thermoelement on the right. These terms are already described by Equations (II-17) and (II-18). Therefore, if T (t) is the average temperature of the barrier we may write:

$$\begin{bmatrix} \text{rate of heat in} \\ (Q_{1}(t)) \end{bmatrix} - \begin{bmatrix} \text{rate of heat out} \\ (Q_{0}(t)) \end{bmatrix} = \begin{bmatrix} \text{rate of heat} \\ \text{heat} \\ \text{accumulation} \end{bmatrix} = \begin{bmatrix} C_{p} \\ \text{AL} \\ \frac{dT(t)}{dt} \end{bmatrix}$$

$$(II-25)$$

The temperature drop across the barrier is approximately:

$$\frac{Q_{i}(t) + Q_{o}(t)}{2} \approx \frac{kA}{L} \left[T_{i}(t) - T_{o}(t)\right]$$
 (II-26)

and further:

$$T (t) \approx \frac{T_i (t) + T_o (t)}{2}$$
 (II-27)

so that the barrier behavior is now completely described.

If the barrier equations for each barrier (between segments) are combined with the equations and boundary conditions applicable to the segments, a set of difference equations is obtained similar to the set obtained for a non-segmented thermoelement, the basic difference being in the coefficients. Once these have been determined, the thermoelement points may be handled simultaneously with all of the other mesh points.

The electrical output and efficiency for the segmented system can now be obtained as easily as for the non-segmented system. The total electrical output is the summation of the electrical outputs of each segment minus the losses already discussed (with the additional assumption that the electrical resistance of the barriers is included in the contact resistance associated with those barriers). The efficiency is the net total electrical output divided by the heat into the hot end of each segment.

B. Absorber and Radiator Analysis

The behavior of the radiator can be handled by identical equations as utilized to analyze the absorber provided proper care is taken in setting up the analysis. Consequently, this discussion will be limited to a consideration of basically the absorber. All assumptions and considerations which are made will be in sufficient depth that the applicable equations may be readily utilized for the radiator as well.

The absorber acts as a heat transfer fin in that it receives radiant energy principally from the sun and transmits a major portion of this energy to the thermoelement hot junction by conduction. The remaining energy is either reradiated from the surface or is radiated directly to the radiator. Since one objective in the design of this system is to minimize weight, it is readily apparent that the absorber thickness must be made as thin as possible consistent with good heat transfer characteristics. Exactly what comprises "good heat transfer characteristics" cannot be determined without a detailed investigation. Investigations performed prior to the analysis reported herein have not considered the temperature gradients which result in the absorber and have therefore been unable to fully evaluate the performance characteristics.

Since the absorber is thin relative to its other dimensions, it may be treated as having a negligible temperature gradient perpendicular to the surface. This reduces the problem to a two-dimensional conduction analysis in Cartesian coordinates since the absorber is a rectangular structure. However, the nature of the reradiation terms from the surface as well as the complexities of the radiant energy interchange effects result in a mathematical representation which cannot be handled using analytic techniques.

The absorber receives heat principally by radiation from the sun, although energy interchange will also result from the albedo (planet reflected solar radiation), from radiation emitted directly by planets which is intercepted by the collector and by interchange between the absorber and the radiator. Although the absorber input may be quite accurately calculated using only the direct solar radiation, the behavior of the radiator can be strongly effected by the surroundings it "sees". Since these surroundings must be incorporated into the radiator analysis, they will also be incorporated into the absorber analysis which will, of course, increase the accuracy of the absorber calculation.

The calculation of the solar energy intercepted by the absorber is relatively straightforward from the standpoint that the flux is relatively well-known and it is only necessary to determine the orientation of the absorber with respect to the incoming solar flux. Knowledge of the relative absorptivity to solar radiation immediately enables one to compute the fraction of the impinging energy which is absorbed. Since the relative absorptivity can be a function of temperature, this dependency will be an allowed variable.

Powers* states that the calculation of "earthshine" is considerably less precise. He further states that fundamental assumptions are normally required to reduce the complexity of the computation. These normally consider that the earth is a diffusely emitting black body with a uniform surface temperature of $450^{\circ}R$. When this assumption has been made, it is immediately possible to compute the direct energy input impinging upon the

^{*} Powers, Edward I., "Thermal Radiation to a Flat Surface Rotating About an Arbitrary Axis in an Eliptical Earth Orbit: Application to Spin-Stabilized Satellites", National Aeronautics and Space Administration, NASA TN D-2147, April 1964.

surface of the absorber from all portions of the earth which are "seen" from the absorber. Similar considerations are applicable to planets other than the earth.

It is immediately apparent that calculation of the effect of albedo requires a similar treatment. Powers in this case assumes that the earth can be represented as a diffusely reflecting sphere with the source intensity represented as a function of the absorber location relative to that portion of the earth which is lit by the sun.

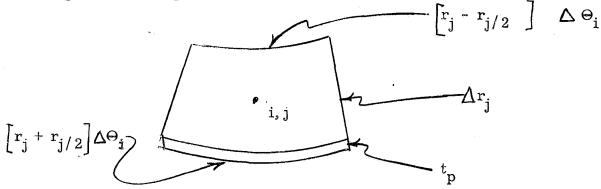
Heat will be reradiated from the surface of the absorber. This may be immediately determined if the temperature is being computed by utilizing the relative emissivity which can be represented as a function of temperature.

Energy interchange will also occur between the absorber and the radiator. Although this calculation may be readily made between two parallel flat plates if the surfaces are at uniform temperatures, the problem becomes more complex if temperature distributions occur, as is the case under consideration here. Since the surfaces of the absorber and radiator which "see" each other will be highly polished to minimize the energy interchange, the actual quantity of heat transmitted between the two surfaces will be small in comparison to the other heat transfer effects. Consequently, if some error occurs in this portion of the analysis, its effect on the overall performance will be minimized. As a result, the assumption will be made that the collector and the radiator can each be represented in terms of the fourth power of temperature integrated over the surface of the plate in question and hence averaged. This integration process is straightforward once the temperature distribution has been established. Immediately, the energy interchange between the two surfaces may now be treated as though the surfaces had a uniform temperature. The overall effect of this assumption is a slight perturbation in the temperature distribution on the surfaces. At the edges which are furthest removed from the thermoelement, the absorber and radiator will normally have the largest temperature difference, and the energy interchange at this point will be slightly greater than computed with the assumption. Conversely, the opposite effect will occur as the portion of the surface in question is considered as approaching the thermoelement.

The basic solar flat plate configuration as presently constructed and analyzed herein can be represented by a rectangular geometry. This would immediately imply that the basic analysis of the absorber should also be based on rectangular geometry. Indeed, initial approaches to the analysis of this problem were made utilizing this assumption. However, a consideration of the heat flux and hence the nature of the temperature gradients within the absorber resulted in a change from this geometry to the cylindrical coordinate system. This apparently contradictory decision was reached from consideration of two different standpoints. First, most of the energy which is absorbed by the absorber is transferred by conduction to the thermoelement. The heat fluxes in the vicinity of the hot end of the thermoelement are therefore high, with large temperature gradients, and these heat fluxes decrease as the distance from the hot end of the thermoelement is increased. This means that a numerical representation of the behavior of the absorber should be based upon selection of small volumes or nodes which are located closely

together. Since the temperature gradients become less as the distance from the thermoelement is increased, nodes which are located further away may be utilized to represent larger volumes with a similar accuracy. Secondly, it was desired that the computer program should be as easily used as possible. This essentially meant that the computer program should be caused to generate its own nodal arrangement based upon a minimum of input data. Both of these considerations immediately imply a cylindrical coordinate system as one which most readily allows the desired node arrangements to be attained. This assumption is discussed further and in more detail later in this report (see also Appendix A).

A heat balance may be taken over a small section of the absorber by considering the following small section:



The following heat balance can be written:

The total heat flux per unit area absorbed by the exposed surface is given by:

$$Q_{i, j}(t) = SOC(\delta, T_{i, j})\beta(\delta)\cos(\delta(t)) + \sigma F_{1}(T_{i, j}, t) Tp(t)^{4} + SRF_{2}(T_{i, j}, t)$$
 (II-29)

where:

Q = absorbed heat flux

S = solar constant

absorptivity (for solar radiation)

δ = incident angle for solar radiation measured from a line perpendicular to the plate surface

T, ; = temperature at position, i, j

 $\beta = 1 \text{ if } 0 \le S < \Omega / 2$ $= 0 \text{ otherwise} \qquad \text{for collector}$

 $\beta = 0 \text{ if } 0 \leq \delta \leq 1/2$ = 1 otherwise for radiator

t = time

σ = Stefan-Boltzmann constant

F₁ = radiation view factor for heat transfer to plate from a planet

T = planet absolute temperature

R = reflectivity constant of planet (albedo)

F₂ = radiation view factor for reflected (solar) heat transfer to plate from planet

Note that Q is not independent of location on the plate since the relative absorptivities are functions of temperature. The heat flow associated with the surface is referred to in the following way to simplify the algebra:

$$q = Q(T_{i,j}, t) r_{j} \Delta r \Delta \Theta$$
 (II-30)

where:

q = the heat absorbed per unit time by the segment for this phenomenon

Heat will also be absorbed from the other plate (if we are considering the absorber, the other plate is the radiator). The net heat transferred can be described by:

$$q = \sigma_{F_{i,j}} (T_{i,j}, T'_{i,j}) \left[T_{i,j} (t)^4 - \overline{T'(t)^4} \right] r_j \Delta r \Delta \Theta \qquad (II-31)$$

where:

F; = view factor

 $T_{i,j}^{r,j}$ = temperature at (r, Θ)

T'4 = effective temperature of other plate taken to the fourth power and averaged

Heat will be radiated from the exposed surface according to:

$$q = \mathbf{G} \in (T_{i,j}) \Delta r r_j \Delta \Theta T_{i,j} (t)^4$$
 (II-32)

where:

= relative emissivity of exposed surface

Heat conducted from the plate segment into other portions of the plate can be described by:

$$q = \sum_{\text{through sides}}$$
 (rate of heat conduction out of segment through sides) (II-33)

which can be written:

$$q = -t_{p} \left\{ k \left(T_{i, j} - \frac{1}{2} \right) \frac{\Delta \Theta}{\Delta r} \left[r_{j} - \frac{\Delta r}{2} \right] \left[T_{i, j - 1} (t) - T_{i, j} (t) \right] + k \left(T_{i, j} + \frac{1}{2} \right) \frac{\Delta \Theta}{\Delta r} \left[r_{j} + \frac{\Delta r}{2} \right] \left[T_{i, j + 1} (t) - T_{i, j} (t) \right] + \frac{k \left(T_{i + \frac{1}{2}, j} \right)}{r_{j}} \frac{\Delta r}{\Delta \Theta} \left[T_{i + 1, j} (t) - T_{i, j} (t) \right] + \frac{k \left(T_{i - \frac{1}{2}, j} \right)}{r_{j}} \frac{\Delta r}{\Delta \Theta} \left[T_{i + 1, j} (t) - T_{i, j} (t) \right] + \frac{k \left(T_{i - \frac{1}{2}, j} \right)}{r_{j}} \frac{\Delta r}{\Delta \Theta} \left[T_{i - 1, j} (t) - T_{i, j} (t) \right] \right\}$$
(II-34)

Finally, heat will be accumulated within the segment due to a change in temperature with respect to time. This effect is:

$$q = C_p(T_{i,j}) \rho(T_{i,j}) t_p r_j \Delta \Theta \Delta r \frac{dT_{i,j}(T)}{dt}$$
(II-35)

All other effects are assumed negligible, as previously discussed.

These effects can be combined accordingly to yield:

$$C_{p} (T_{i,j}) P (T_{i,j}) t_{p} r_{j} \Delta \Theta \Delta r \frac{dT_{i,j}(t)}{dt} = Q (T_{i,j}, t) r_{j} \Delta r \Delta \Theta - C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta \Theta - C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta \Theta - C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta R + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r \Delta r + C_{p} (T_{i,j}, t) r_{j} \Delta r + C_{p}$$

$$-CC_{0}\left(T_{i,j}\right) \triangle r \ r_{j} \triangle \Theta \ T_{i,j}(t)^{4} + t_{p} k \left(T_{i,j} - \frac{1}{2}\right) \frac{\triangle \Theta}{\triangle r}$$

$$\left[r_{j} - \frac{\Delta r}{2}\right] \left[T_{i,j-1}(t) - T_{i,j}(t)\right] + k \left(T_{i,j} + \frac{1}{2}\right) \frac{\Delta \Theta}{\Delta r}$$

$$\left[r_{j} + \frac{\Delta r}{2}\right] \left[T_{i,j+1}(t) - T_{i,j}(t)\right] + \frac{k \left(T_{i+\frac{1}{2},j}\right)}{r_{j}} \frac{\Delta r}{\Delta \Theta}$$

$$\left[T_{i+1,j}(t) - T_{i,j}(t)\right] + \frac{k \left(T_{i-\frac{1}{2},j}\right)}{r_{j}} \frac{\Delta r}{\Delta \Theta} \left[T_{i-1,j}(t) - T_{i,j}(t)\right]$$

$$-T_{i,j}(t)$$

$$-T_{i,j}(t)$$

$$-T_{i,j}(t)$$

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$$-T_{i,j}(t)$$

which may be transformed to the following differential equation by dividing by $r_{ip}^{t} \Delta \Theta \Delta r$ and allowing Δr and $\Delta \Theta$ to approach zero:

$$C_{p}(T) P(T) \frac{\partial T(\Theta, r, t)}{\partial t} = \frac{Q(T, t)}{t_{p}} - \frac{\sigma}{t_{p}} \quad F(\Theta, r, T, T')$$

$$\left[T(\Theta, r, t)^{4} - T'^{4}\right] + S(\Theta, r, t) - \frac{\sigma}{t_{p}} \quad \mathcal{E}_{o}(T) T(\Theta, r, t)^{4} + \frac{1}{r_{j}} \frac{\partial}{\partial r} \left\{r_{k}(T) \frac{\partial T(\Theta, r, t)}{\partial r}\right\} + \frac{1}{r_{j}^{2}} \frac{\partial}{\partial \Theta} \left\{k(T) \frac{\partial T(\Theta, r, t)}{\partial \Theta}\right\}$$

which is the governing differential equation describing heat transfer in the absorber. Note that the direct functional dependencies are indicated. Hence, $F(\Theta, r, T, T')$ indicates that F is a function of the independent variables Θ and r, and of the dependent variables T and T'. F is not directly a function of time, although it will vary with time because T and T' would be completely written as $T(\Theta, r, t)$ and T'(t).

The view factor F may be written as:

$$F_{i,j} = \frac{1}{\xi_0^{(T)} + \frac{1}{\xi_1^{-1}} - 1}$$
 (II-38)

where £ ' is the average relative emissivity of the absorber.

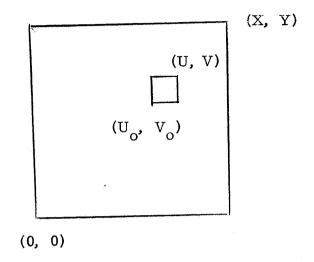
Similar equations for the radiator may be obtained by exchanging the T and T' terms and applying the other parameters properly.

The boundary conditions necessary to obtain solutions to the equations which represent the absorber or radiator essentially consist of the previously discussed interconnections between these surfaces and the thermoelements as well as the additional assumptions that no heat is lost from the edges of the array which are exposed to the surroundings. This latter assumption is relatively good since the internal portions of the array do not "see" space to a significant degree. The view factor for the internal portions to space is further decreased by the lip that is formed around the edge of the collector which serves as a stiffening member. By the same token, a portion of the heat that is collected by the absorber will be perturbed by the presence of this lip, although this has not been considered in the analysis since the effect will be small.

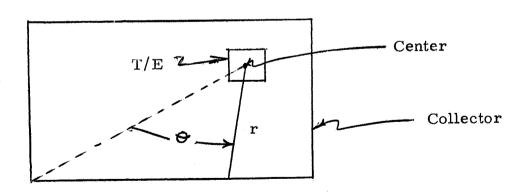
C. Mesh Set Up Technique

As previously discussed, heat conduction within either the absorber or the radiator may be described by taking a heat balance over a small representative section and then considering the equations which result as the section size is caused to approach zero. The resulting differential equation cannot be solved by present analytical techniques, and a numerical solution is therefore required. The solution selected basically consists of the expansion of the derivative terms through a Taylor series expansion with the rejection of higher order terms. This technique is commonly used for heat transfer calculations and yields excellent accuracy provided the increment sizes are properly selected. It further introduces relatively simple computation techniques which in turn speed up the solution through faster computation. A basic consideration is the selection of a suitable mesh arrangement which then forms the basis for the application of the differential equation.

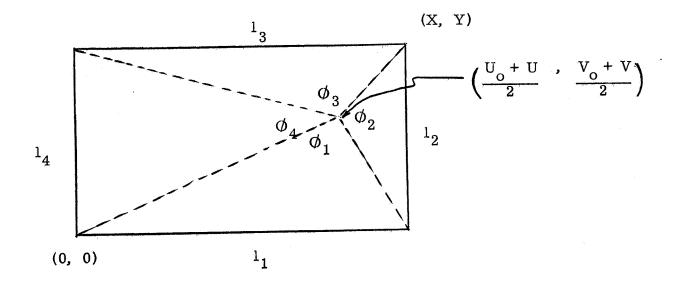
For reference purposes the absorber will be considered as oriented in a Cartesian (x, y) coordinate system with the origin located at the lower left corner. Specification of the plate size may be immediately made by defining the point (X, Y) as the coordinate of the upper right corner. The lower left corner of the thermoelement will be specified by (U_0, V_0) , and the upper right corner will be specified by (U, V). This defines the overall dimensions of the absorber, as seen from the following sketch:



The calculations will be performed using radial geometry and selecting the radial increment, Δr , such that the controlling angular increment will approximately form a square. The controlling angular increment will be defined as the average value of $\Delta \Theta$ encountered in $0 \leq \Theta \leq 2 \%$:



To determine the $\Delta \Theta$'s we next consider:



where the l_i are the number of increments each of the i sides is to be divided into for calculation purposes. We can use the law of cosines to write:

$$\cos \phi_1 = \frac{4x^2 - (U_o + U)^2 - (2x - U_o - U)^2 - 2(V_o + V)^2}{-2\sqrt{(U_o + U)^2 + (V_o + V)^2}\sqrt{(2x - U_o - U)^2 + (V_o + V)^2}}$$
 (II-39)

$$\cos \phi_2 = \frac{4y^2 - 2(2X - U_o - U)^2 - (V_o + V)^2 - (2Y - V_o - V)^2}{-2\sqrt{(2X - U_o - U)^2 + (V_o + V)^2}\sqrt{(2Y - V_o - V)^2 + (2X - U_o - U)^2}}$$
 (II-40)

$$\cos \phi_3 = \frac{4x^2 - 2(2Y - V_o - V)^2 - (2X - U_o - U)^2 - (U_o + U)^2}{-2\sqrt{(2Y - V_o - V)^2 + (2X - U_o - U)^2}\sqrt{(U_o + U)^2 + (2Y - V_o - V)^2}}$$
 (II-41)

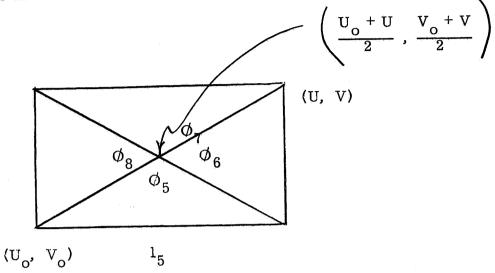
$$\phi_4 = 2 \pi - \phi_1 - \phi_2 - \phi_3$$
 (II-42)

Now define:

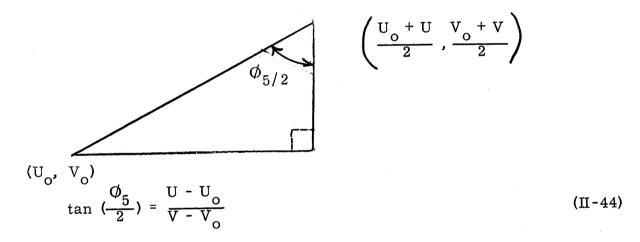
$$\Delta \Theta_{i}' = \frac{\Phi_{i}}{I_{i}} \qquad 1 \stackrel{4}{=} i \stackrel{4}{=} 4 \qquad (II-43)$$

These are the $\triangle \Theta_i$ required by the l_i .

We now consider the thermoelement:



or, perhaps a little easier:



Similarly:

$$\tan \left(\frac{\phi_6}{2}\right) = \frac{V - V_0}{U - U_0} \tag{II-45}$$

$$\phi_7 = \phi_5 \tag{II-46}$$

$$\phi_8 = \phi_6 \tag{II-47}$$

and:

$$\Delta \Theta_{i}' = \frac{\Phi_{i}}{l_{i}} \qquad \qquad 5 \leq i \leq 8 \qquad (II-48)$$

We now compare $\Delta\Theta_1$ and $\Delta\Theta_5$ and select the smaller of the two values to apply as $\Delta\Theta_1$ for $0 = \Theta = \Phi_1$. If $\Delta\Theta_5$ is selected, a new l_1 corresponding to $\Delta\Theta_5$ will be computed. The new l_1 will be truncated to the next larger integer if it is not already an integer, and the $\Delta\Theta_5$ will be recomputed using the truncated l_1 . This $\Delta\Theta_5$ will become $\Delta\Theta_1$.

Similar manipulations will be performed for ϕ_2 , ϕ_3 and ϕ_4 .

Typical of the type of angular arrangement which could result from this specification is the geometry shown in Figure II-1. Note that the size of the rays on each side of line "A" are different. If carried to an extreme, this would mean that adjoining segments constructed on this angular arrangement could be of drastically different size. There would immediately result an error in the representation of the differential equation by node arrangements of this type. As a consequence, it is desirable that the variation from ray to ray be minimized. This can be accomplished through an iterative averaging technique which will result in the same number of rays/side, but will arrange the size somewhat differently. To accomplish this, we first define:

$$n_0 = 0$$
 $n_1 = 1_1$
 $n_2 = n_1 + 1_2$
 $n_3 = n_2 + 1_3$
 $n_4 = n_3 + 1_4$
 $\Delta \Theta_i = \overline{\Delta} \Theta_j$
 $1 = j = 4$
 $n_{j-1} + 1 = i = n_j$

(II-50)

Now we select j = 1 and perform the following calculations:

$$\Delta \Theta_{i} = \frac{1}{2} \left[\Delta \Theta_{i+1} + \Delta \Theta_{i-1} \right]$$
 (II-51)

for $i = n_{j-1} + 1$, then $n_{j-1} + 2$, $n_{j-1} + 3$, . . . , to n_{j} (inclusive).

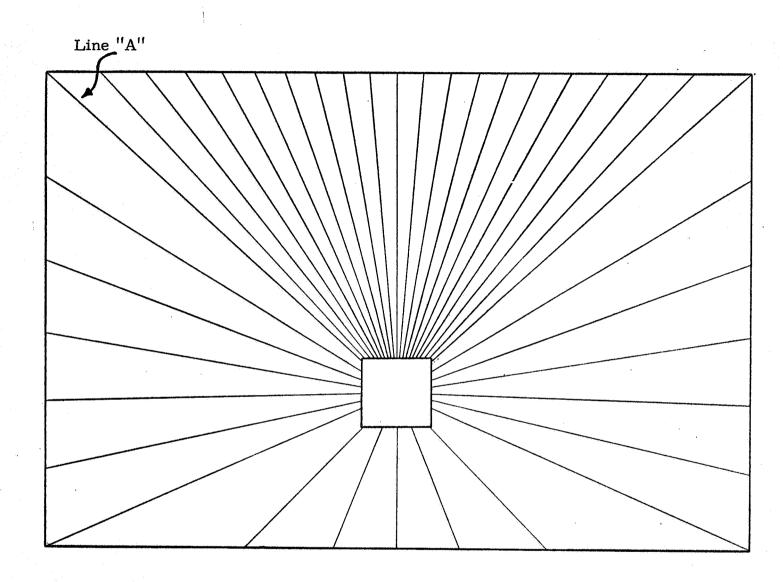


Figure II-1 Non-Smoothed Angles

A subscript zero will be taken to mean n_4 , and a subscript $n_4 + 1$ to mean one. We now compute:

$$\phi = \sum_{i=n_{j-1}+1}^{n_j} (\Delta \Theta_i)$$
(II-52)

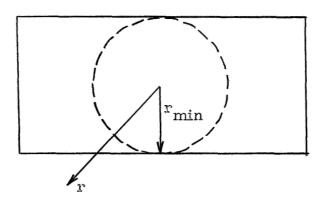
and we renormalize according to:

$$\Delta \Theta_{i} = \frac{\phi_{j}}{\phi} \Delta \Theta_{i} \qquad \qquad n_{j-1} + 1 \stackrel{\checkmark}{=} i \stackrel{\checkmark}{=} n_{j} \qquad (II-53)$$

where the meaning of Equation (II-53) is to compute the right hand side and then replace $\Delta \Theta_i$ by that value.

We now repeat Equations (II-51) through (II-53) for j=2, j=3, and j=4. Then we repeat for j=1, 2, 3, 4, and we continue the process until convergence has been obtained. This could typically result in the behavior illustrated in Figure II-2. Note that the variation of size from ray to ray has been smoothed, and no large discontinuities exist. The desired number of rays per side is still the same.

This process will set up the $A\Theta_i$. We next must compute the r_j. To $U-U_0$ do this we first compute an initial radius as the minimum of $\frac{U-U_0}{2}$ and $\frac{V-V_0}{2}$. This is then the minimum value the radius can have and still be in the plate, but outside of the thermoelement.



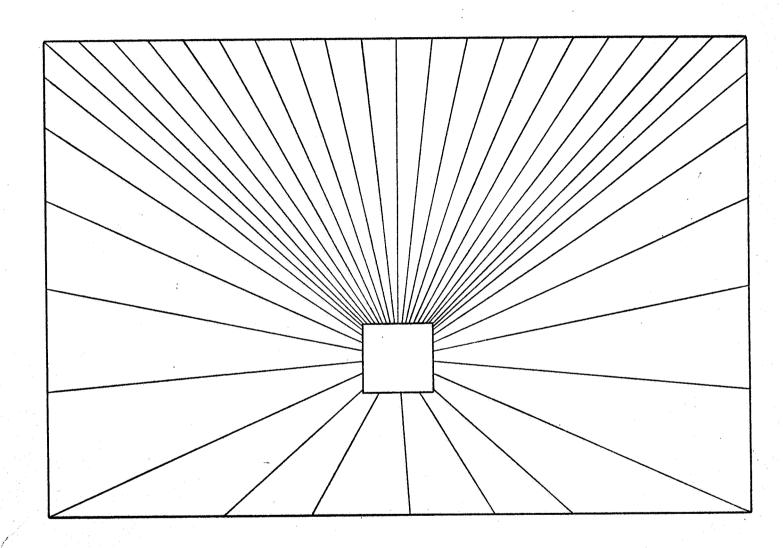


Figure II-2. Illustration of "Smoothed" Angles

We will base Δr_j on the average $\Delta \Theta_i$, $\triangle r_j$ will be calculated by:

$$\Delta r_j = r_j \quad \overline{\Delta \Theta}$$
 (II-54)

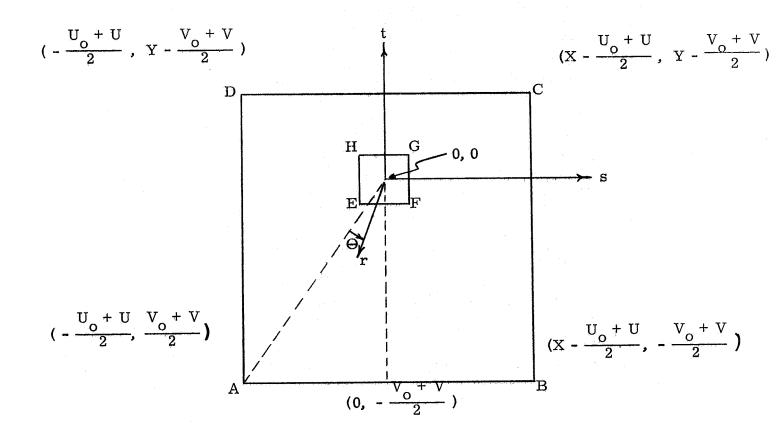
Thus, we see that Δr_j will increase as we move away from the thermoelement center. The initial Δr_j , will be calculated from r_{\min} .

Then we can use:

$$r_{j+1} = r_j + \Delta r_j \tag{II-55}$$

to compute all of the other r, of course recomputing & r, each time.

To set up the mesh and take into account the thermoelement and the plate edges requires a knowledge of where they are located relative to the center of rotation. This may be accomplished by a transformation of coordinates to (r, Θ) geometry with the center at $x = \frac{U_0 + U}{2}$, $y = \frac{V_0 + V}{2}$:



where the coordinates are given in terms of the (s, t) system, a rectangular system with the same zero point as the (r, Θ) system and otherwise oriented parallel to the (x, y) system. In (r, Θ) geometry, the values for points A - D are obvious. To obtain E - H, we first note that when the radius vector is straight down:

$$\tan\Theta = \frac{U_0 + U}{V_0 + V} \tag{II-56}$$

Or:

$$\Theta = \tan^{-1} \left(\frac{U_0 + U}{V_0 + V} \right) \tag{II-57}$$

But at this point, we also have a known $\phi_5/2$ (See Equation (II-44)):

$$\frac{\phi_5}{2} = \tan^{-1} \left(\frac{U - U_0}{V - V_0} \right)$$
 (II-58)

The value of Θ corresponding to E may be obtained by subtracting:

$$\Theta_{\rm E} = \tan^{-1} \left(\frac{U_{\rm o} + U}{V_{\rm o} + V} \right) - \frac{\phi_5}{2}$$
 (II-59)

But we will not be concerned here with negative Θ 's. Hence we will stipulate that if Θ_E is negative as calculated, then corner E will be shifted to position F, F to G, etc. Immediately, corner F is located at $\Theta = \Theta_E + \emptyset_5$, etc. Since the center of the coordinate system is located in the center of thermoelement, the radii for the four corners are identical and may be obtained immediately. These data are summarized in Table II-1.

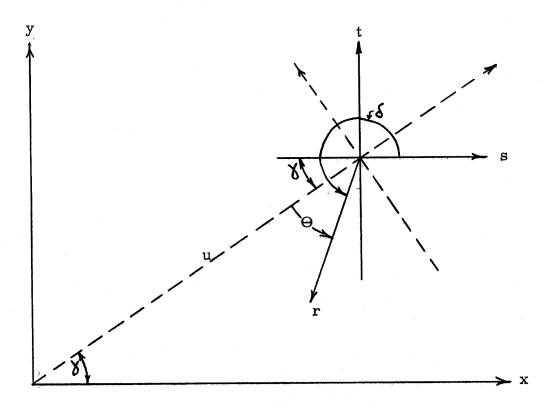
If (u, v) represents a rectangular coordinate system based upon the same zero as the polar coordinate system being considered here, then we may write:

$$u = r \cos \Theta \tag{II-60}$$

$$v = r \sin \Theta \tag{II-61}$$

TABLE II-1. POSITION OF CORNERS IN (r, Θ) GEOMETRY

Corners	Θ	r
A	0	$\frac{1}{2}\sqrt{(U_0 + U)^2 + (V_0 + V)^2}$
В	ϕ_1	$\sqrt{(X - \frac{V_0 + V}{2})^2 + (\frac{V_0 + V}{2})^2}$
C	$\phi_1 + \phi_2$	$\sqrt{(X - \frac{U_0 + U}{2})^2 + (Y - \frac{V_0 + V}{2})^2}$
D	$\phi_1 + \phi_2 + \phi_3$	$\sqrt{\left(\frac{U_{o} + U}{2}\right)^{2} + \left(Y - \frac{V_{o} + V}{2}\right)^{2}}$
E	$\Theta_{ m E}$	$\frac{1}{2} \sqrt{(U - U_0)^2 + (V - V_0)^2}$
F	$\Theta_{\mathrm{E}}^{}+\phi_{5}^{}$	$\frac{1}{2} \sqrt{(U - U_0)^2 + (V - V_0)^2}$
G	$\Theta_{\rm E} + \Phi_5 + \Phi_6$	$\frac{1}{2}\sqrt{(U-U_0)^2+(V-V_0)^2}$
Н	$\Theta_{\rm E}$ + $2\Phi_5$ + Φ_6	$\frac{1}{2}\sqrt{(U-U_0)^2+(V-V_0)^2}$



and if (s, t) represents a rectangular coordinate system based at the same zero as the polar coordinate system, but rotated clockwise from the (u, v) system by N+V, then:

$$\mathbf{S} = \Theta + \mathbf{Y} + \mathbf{\Upsilon} \tag{II-62}$$

but:

$$\tan \mathbf{r} = \frac{V_o + V}{U_o + U} \tag{II-63}$$

$$\gamma = \tan^{-1} \left(\frac{V_0 + V}{U_0 + U} \right) \tag{II-64}$$

and:

$$S = \Theta + \tan^{-1} \left(\frac{V_o + V}{U_o + U} \right) + 1$$
 (II-65)

Further:

$$s = r \cos \mathcal{L} \tag{II-66}$$

$$t = r \sin \delta$$
 (II-67)

Or:

$$s = r \cos \left[\Theta + \mathcal{V}_{+} \tan^{-1} \left(\frac{V_{o} + V}{U_{o} + U} \right) \right]$$
 (II-68)

$$t = r \sin \left[\Theta + V + \tan^{-1} \left(\frac{V_o + V}{U_o + U}\right)\right]$$
 (II-69)

We may also write:

$$t = y - \frac{V_0 + V}{2}$$
 (II-70)

$$s = x - \frac{U_0 + U}{2} \tag{II-71}$$

So that:

$$x = r \cos \left[\Theta + M + tan^{-1} \left(\frac{V_o + V}{U_o + U}\right)\right] + \frac{U_o + U}{2}$$
 (II-72)

$$y = r \sin \left[\Theta + W + tan^{-1} \left(\frac{V_o + V}{U_o + U}\right)\right] + \frac{V_o + V}{2}$$
 (II-73)

But:

$$\sin (u + v) = \sin (u) \cos (v) + \cos (u) \sin (v)$$
 (II-74)

$$\cos (u + v) = \cos (u) \cos (v) - \sin (u) \sin (v)$$
 (II-75)

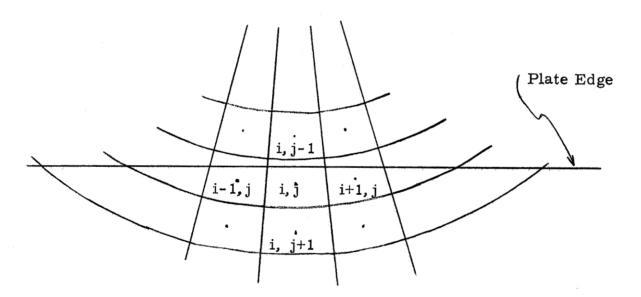
and:

$$x = -r \left\{ \cos (\Theta) \cos (\tan^{-1} (\frac{V_o + V}{U_o + U})) \right\}$$

$$- \sin (\Theta) \sin (\tan^{-1} (\frac{V_o + V}{U_o + U})) + \frac{U_o + U}{2}$$
(II-76)

$$y = -r \left\{ \sin(\Theta) \cos(\tan^{-1}(\frac{V_{o} + V}{U_{o} + U})) + \cos(\Theta) \sin(\tan^{-1}(\frac{V_{o} + V}{U_{o} + U})) \right\} \frac{V_{o} + V}{2}$$
(II-77)

The plate edges will not fit into the mesh selected for analysis in a regular manner, and we must investigate these in more detail in order to generate a mesh which accurately represents the edge behavior as well as internal behavior. We first consider the following:



The plate edge is a straight line which, if horizontal, can be represented simply by:

$$y = C (II-78)$$

or, if vertical, by:

$$x = g (II-79)$$

Substituting these, we immediately obtain:

r =
$$\frac{C - \frac{V_o + V}{2}}{\sin(\Theta) \cos(\tan^{-1}(\frac{V_o + V}{U_o + U})) + \cos(\Theta) \sin(\tan^{-1}(\frac{V_o + V}{U_o + U}))}$$
 (II-80)

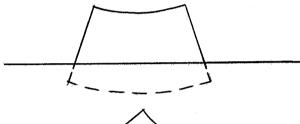
for a horizontal line and:

$$r = \frac{g - \frac{U_o + U}{2}}{\cos(\Theta) \cos(\tan^{-1}(\frac{V_o + V}{U_o + U})) - \sin(\Theta) \sin(\tan^{-1}(\frac{V_o + V}{U_o + U}))}$$
(II-81)

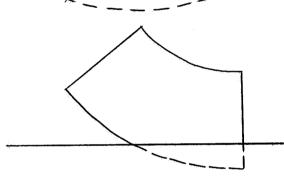
for a vertical line.

There are a number of possibilities or ways in which the horizontal line may intersect the mesh:

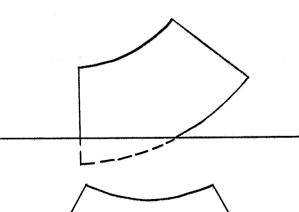
A)



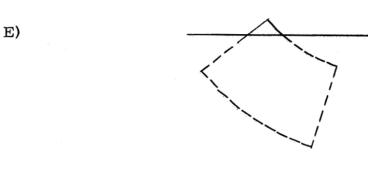
B)

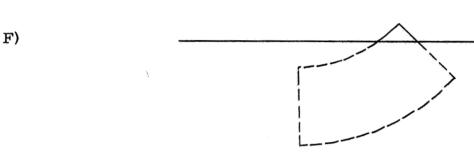


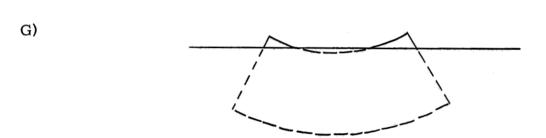
C)



D)







In each case the area enclosed by the solid line must be computed and included within the mesh. Although these areas can be computed exactly, the size of the increments is small and small errors in the size of several increments will have negligible effect on the overall plate behavior. We will therefore assume the segment shape to be trapezoidal. This immediately eliminates cases D and G as having a negligible effect on the mesh.

The following types of behavior can take place in fitting trapezoidal nodes to the plate-thermoelement intersection:

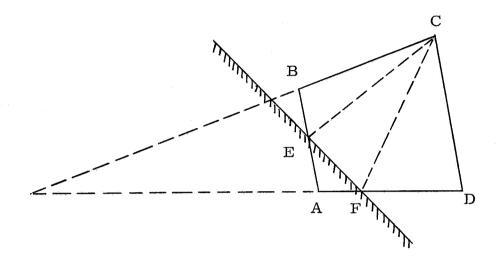
(1) Both inside corners in T/E, outside corners outside:

T/E Edge (shaded portion shows T/E material BE Segment

Center of T/E

Solution: Redefine points A, B; treat as case 8.

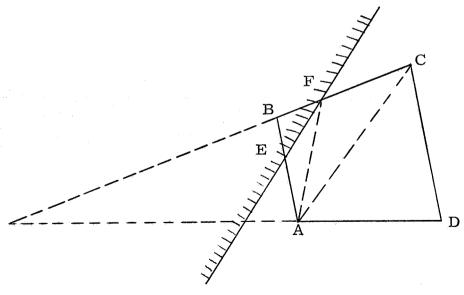
(2) Back inside corner in T/E, others outside:



Solution: Compute area for several triangles, and add to obtain the total:

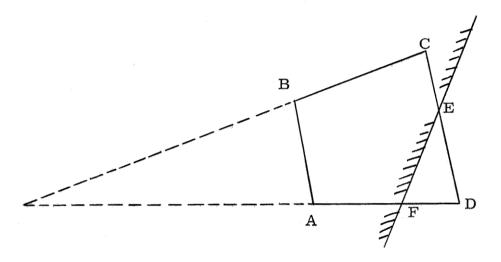
$$area = BCE + CEF + CDF$$
 (II-82)

(3) Forward inside corner in T/E, others outside:



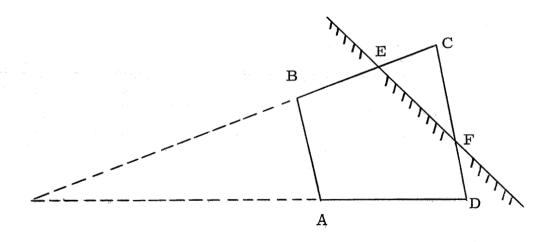
area = AEF + ACF + ACD (II-83)

(4) Back outside corner outside T/E, others inside:



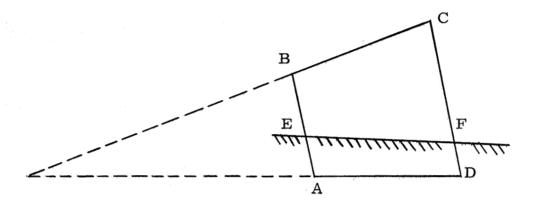
area = DEF (II-84)

(5) Forward outside corner outside T/E, others inside:



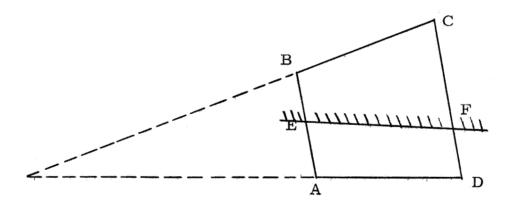
area = CEF (II-85)

(6) Backward corners in T/E, forward corners outside:



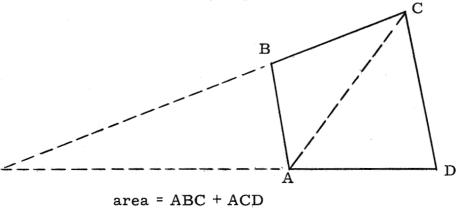
Redefine A, D; treat as case 8.

(7) Backward corners outside, forward corners in T/E:



Redefine B, C; treat as case 8.

(8) Finally, there is the simple case of a node that does not intersect any edges:



(II-86)

Similar construction techniques can be used to describe node behavior along the plate edge. First refer to the same sketches and apply them to the plate edge. If we assume that the shaded side is within the plate, then the following may be defined:

Case	Area
11	Redefine C, D, Treat as 8
21	AEF
31	BEF
41	ABC + ACE + AEF
51	ABE + AEF + ADF
61	-
71	-

There additionally exist the possibilities that a node may be common to the plate edge and the T/E edge, or that the plate edge and the T/E edge correspond. If they correspond, there is no node at that location. If the node is common to both edges, then there exist possibilities in the plate edge treatment where neither 1 - 7 or 1' - 7' are useful. It may be more convenient to subtract the position outside the plate edge from a previously computed area than to compute the area inside the plate directly. These cases will be treated using a double prime with the understanding that the indicated area is to be subtracted. The area in each case is described by the non-prime cases, but with the edge being the edge of the plate, not the edge of the T/E. In a few of these cases, it will also be convenient to merely move the points A B C D to correspond to the plate and T/E edges. In these cases, the treatment is the same as though no edges were present after the redefinition of the points has been made.

Since all nodes may be considered by considering triangles, we next consider the characteristics which must be calculated. The area of a triangle is:

$$A = \sqrt{s \left[s - a \right] \left[s - c \right]}$$
 (II-87)

where:
$$s = \frac{1}{2} [a + b + c]$$
 (II-88)

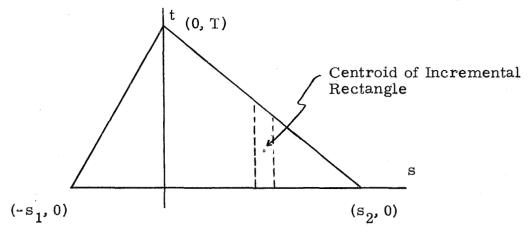
and a, b and c are the lengths of the sides. Once the coordinates of the corners have been obtained, the length of a line between the points may be determined from:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$
 (II-89)

where d is the line length, and the line ends are at (x_2, y_2) and (x_1, y_1) .

The selection of whether to treat the partial segment as a separate segment or as part of another segment may now be made. Some of these segments will be very small and if considered separately would require very small time steps. Consequently, we will make an arbitrary selection. If the area of a partial segment is less than one whalf that of the j-1 segment, then it will be attached to and made a part of the j-1 segment. This arbitrary selection is made with a small enough segment size that little error will be introduced by incorporating the segment into another segment.

The "center" of each of the segments modified by this procedure must be redetermined so that it is representative of the average behavior of the segment. We first determine the center of the partial segment without regard to its ultimate disposition. Since all areas were determined using triangles as a calculation base, we first determine the center of the triangle:



The moment of the incremental rectangle about the s axis is at $\frac{t}{2}$ dA = $\frac{t^2}{2}$ ds; about the t axis it is at s dA = stds. The equation of the left line is:

$$t = \frac{T}{S_1} s + T \tag{II-90}$$

and that of the right line:

$$t = +T - \frac{T}{S_2} \quad s \tag{II-91}$$

The area is:
$$A = \frac{T}{2} \left[S_1 + S_2 \right]$$
 (II-92)

The moment about the s axis is: So

$$M_{s} = \int_{-S_{1}}^{0} \frac{t^{2}}{2} ds + \int_{0}^{S_{2}} \frac{t^{2}}{2} ds$$
 (II-93)

Therefore:

$$M_{s} = \frac{1}{2} \int_{-S_{1}}^{0} \left[\frac{T}{S_{1}} + T \right]^{2} ds + \frac{1}{2} \int_{0}^{S_{2}} T - \frac{T}{S_{2}} s \right]^{2} ds \qquad (II-94)$$

$$M_{t} = \int_{-S_{1}}^{0} stds + \int_{0}^{S_{2}} stds$$
 (II-95)

$$M_{t} = \frac{T[S_{2}^{2} - S_{1}^{2}]}{6}$$
 (II-96)

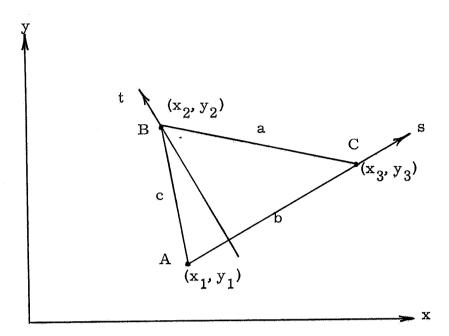
The centroids are now:

$$\overline{t} = \frac{2 T^2 \left[S_1 + S_2 \right]}{6 T \left[S_1 + S_2 \right]} = \frac{T}{3}$$
 (II-97)

$$\overline{s} = \frac{1}{3} \left[S_2 - S_1 \right] \tag{II-98}$$

These centroids are based upon a triangle with an orientation as shown in the previous sketch. The orientations necessary here will be located on a different coordinate system with a different zero point and in most cases with a different rotational orientation. These results will not be applied using the (s, t) system, but the results are simple and can be easily applied to the coordinate system under consideration.

Now suppose the corners of the triangle are located at (x_1, y_1) , (x_2, y_2) and (x_3, y_3) . We will arbitrarily choose x_2 as corresponding to s = 0 and y_2 as corresponding to t = T. Further, (x_1, y_1) will correspond to $(-S_1, 0)$ and (x_3, y_3) to $(S_2, 0)$.



from the law of cosines:

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$$
 (II-99)

Further:

$$a = \sqrt{(x_2 - x_3)^2 + (y_2 - y_3)^2}$$
 (II-100)

$$b = \sqrt{(x_1 - x_3)^2 + (y_1 - y_3)^2}$$
 (II-101)

$$c = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$
 (II-102)

$$S_1 = c \cos A \tag{II-103}$$

$$S_2 = b - S_1$$
 (II-104)

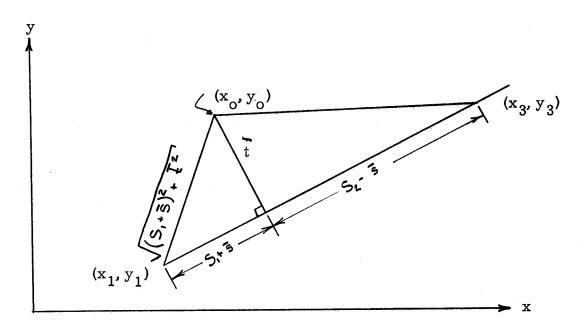
$$T = c \sin A \tag{II-105}$$

But:
$$\sin^2 A + \cos^2 A = 1$$
 (II-106)

$$\sin A = \sqrt{1 - \cos^2 A} \tag{II-107}$$

$$T = c \sqrt{1 - \cos^2 A}$$
 (II-108)

With Equations (II-100) through (II-108) we can immediately find \overline{s} and \overline{t} from Equations (II-98) and (II-97). We may now convert these to the (x, y) coordinate system.



$$\sqrt{(S_1 + \overline{s})^2 + \overline{t}^2} = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} = \sqrt{D}$$
 (II-109)

$$\sqrt{(S_2 - \overline{s})^2 + \overline{t}^2} = \sqrt{(x_3 - x_0)^2 + (y_3 - y_0)^2} = \sqrt{G}$$
 (II-110)

$$x_1^2 - 2x_0 x_1 + x_0^2 + y_1^2 - 2y_0 y_1 + y_0^2 = D$$
 (II-111)

$$x_3^2 - 2x_0 x_3 + x_0^2 + y_3^2 - 2y_0 y_3 + y_0^2 = G$$
 (II-112)

$$x_0 = \frac{D - G - x_1^2 + x_3^2 - y_1^2 + y_3^2 + 2y_0 \left[y_1 - y_3 \right]}{-2 \left[x_1 - x_3 \right]}$$
 (II-113)

This can be written as:

$$x_0 = E + F y_0$$
 (II-114)

and we may substitute this into Equation (II-111) to obtain:

$$x_1^2 - 2x_1 \left[E + Fy_0\right] + \left[E + Fy_0\right]^2 + y_1^2 - 2y_0 y_1 + y_0^2 = D$$
 (II-115)

$$\begin{bmatrix} F^2 + 1 \end{bmatrix} y_0^2 + \begin{bmatrix} -2x_1F + 2E & F - 2y_1 \end{bmatrix} y_0 + + x_1^2 - 2x_1E + E^2 + y_1^2 - D = 0$$
(II-116)

which can be written:

$$a y_0^2 + b y_0 + C = 0$$
 (II-117)

with the solution:

$$y_0 = \frac{-b + b^2 - 4ac}{2a}$$
 (II-118)

To determine which solution is to be used we first note that y_0 must be between y_1 and y_3 , y_1 and y_2 , or y_2 and y_3 ; and x_0 must be between x_1 and x_3 , x_1 and x_2 , or x_2 and x_3 . It is not likely both the y_0 's will satisfy this requirement and we will not investigate this further unless a problem is found to exist in the actual calculations.

There can be a problem if $x_1 = x_3$ because of a zero in the denominator of Equation (II-113). In this case we write:

$$y_1^2 - y_3^2 - 2y_0 [y_1 - y_3] = D - G$$
 (II-119)

$$\frac{y_1^2 - y_3^2 - D + G}{2 y_1 - y_3} = y_0$$
 (II-120)

$$x_0^2 + (-2x_1) x_0^2 + (x_1^2 + y_1^2 - 2y_0 y_1 + y_0^2 - D) = 0$$
 (II-121)

and:

$$x_0 = \frac{-bt - bt^2 - 4 * at * ct}{2 * at}$$
 (II-122)

With the "center" of the triangle determined to be (x_0, y_0) , we may now determine the new center of the segment. This will be located at:

$$x_s = x_n A_n + x_0 A_t$$
 (II-123)

$$y_s = y_n A_n + y_0 A_t$$
 (II-124)

where:

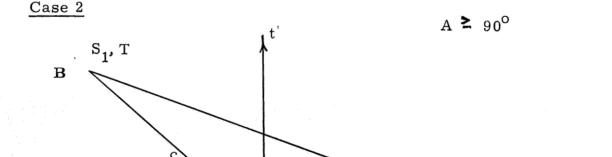
s refers to the edge segment center

n refers to the original node

A_t = triangle area, positive if the triangle is to be added, negative if removed from the original node.

If a trapezoid is to be added or removed, the location of the center is a simple addition of two triangles and will not be discussed here.

Two other "types" of triangles can result during the calculation process, which will be referred to as Cases 2 and 3. Similar investigations result in the following:



A 0, 0

 $s_1 = c (-cos A)$ (II-125)

b

S₂, 0

$$s_2 = b$$
 (II-126)

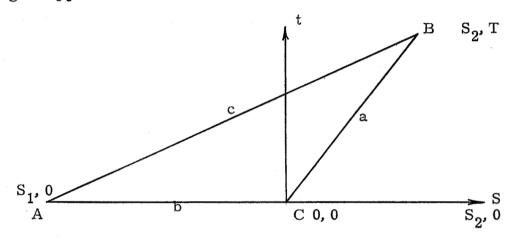
$$T = c \left(1 - \cos^2 A\right)$$
 (II-127)

$$\overline{s} = \frac{s_1 s_2 - s_1^2}{3(s_1 + s_2)}$$
 (II-128)

$$\frac{1}{t} = \frac{T s_1}{3 (s_1 + s_2)}$$
 (II-129)

Case 3

 $C \ge 90^{\circ}$

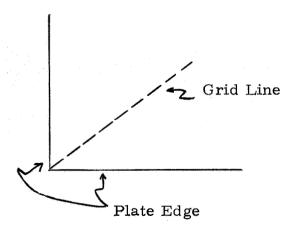


$$s_1 = b$$
 (II-130)

$$s_2 = a (-cos C)$$
 (II-131)

$$T = a \sqrt{1 - \cos^2 C}$$
 (II-132)

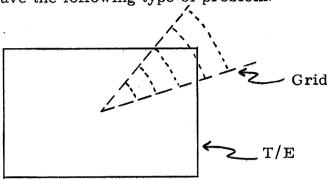
Plate corners will introduce no problem in mesh construction because of the angular construction technique. In all cases along the outside edges, the node construction is of the type:



$$\overline{S} = \frac{S_2^2 - S_2 S_1}{3(S_2 + S_1)}$$
 (II-133)

$$\frac{t}{t} = \frac{t}{3} \frac{S_2}{S_1 + S_2}$$
 (II-134)

for all four corners. However, this is not the case for the thermoelement edge, and here we can have the following type of problem:

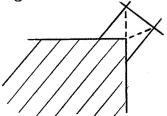


which must be considered. The following cases can result:

(1)

(2)

Case two will be treated by merely adding the triangular segments to the adjoining segment (the increased r position) and adjusting the segment center location accordingly (as previously discussed). Case one can be considered by the following construction:



which gives three triangles and which may be immediately considered by the techniques already discussed.

Unfortunately, the ability to compute the various node characteristics is not worthwhile if the computer cannot be instructed to select the type of node.

To determine the type of node under consideration, we first compare point A on the trapezoid to the thermoelement edge at the same angular location and the corresponding plate edge. An index value, n_A , is assigned according to the following:

Location	Index, n _A
In plate	1
In T/E	2
Outside plate	3

Values on an edge are treated as though they were in the plate. Similar assignments are then made for points B, C and D. We may then compute a "case index", MZU, according to the equation:

$$MZU = n_D + 3 (n_C - 1) + 9 (n_B - 1) + 27 (n_A - 1)$$
 (II-135)

There results the values shown in Table II-2. The item is the case to be treated, and these are defined in Table II-3. The item numbers also correspond to the source program statement numbers in subroutine MESHA. The branching is performed by using MZU as the index for a computed go to statement (see source statement number 24).

TABLE II-2. CORNER TREATMENT CHARACTERISTICS

n _A n _B n _C n _D	MZU	Item	ⁿ A ⁿ B ⁿ C ⁿ D	MZU	Item
1 1	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	36 37 38 37 37 39 37 40 41 37 42 68 37 69 37 43 37	2 2 2 3 1 2 2 3 2 2 3 3 2 3 1 1 2 3 1 2 2 3 3 2 2 2 3 3 3 1 2 3 3 3 1 2 3 3 3 1 1 1 1	42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 60 61	56 57 58 59 37 37 37 37 70 60 61 37 37 62 37 37
1 3 1 1 1 3 1 2 1 3 1 3 1 3 2 1 1 3 2 2 1 3 3 1 1 3 3 2 1 3 3 2 1 1 2 1 2 1 1 2 2 1 2 1 2 1 3 2 2 1 3 3 2 1 2 2 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 1 3 3 2 <			3 1 2 3 3 1 3 2 3 1 3 2 3 2 1 1 3 2 1 2 3 2 2 1 3 2 2 2 3 2 2 2 3 2 3 1 3 3 1 1 3 3 1 3 3 3 2 3 3 3 2 3 3 3 2 3 3 3 3 2 3 3 3 3 3 3 3 3 3 3 3 3	60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81	

TABLE II-3. <u>ITEM DEFINITIONS</u>

	Item	
		Program
Statem	ent Nun	nber)
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Case
8 impossible mesh specification 4' 5' 1' 3 3 - 4'' 3 - 1'' 6' 2'
2 6 2 - 5'' 6 - 5'' 2 - 1'' 1 5 1 - 4''
4 all T/E 4 - 4" 1 - 5" 5 - 5" 1 - 1" 6 - 6" 2 - 2" 7' 3' 3 - 7" 7 - 7" 3 - 3" all outside
3' 3 - 7'' 7 - 7'' 3 - 3'' all outside 7 7 - 4'' 2 - 6''

D. Steady State Calculations

Equation (II-16) may be rewritten in the following form in the steady state:

$$\frac{\frac{k_{n+1}+k_{n}}{2\Delta Z}\left[T_{n+1}-T_{n}\right]-\frac{k_{n}+k_{n-1}}{2\Delta Z}\left[T_{n}-T_{n-1}\right]+}{+\frac{\frac{P_{n}-I^{2}}{A^{2}}}{A^{2}}-\frac{T_{n}I}{2A}\left[\propto_{n+1}-\infty_{n-1}\right]-\frac{FP}{A}}$$

$$\left[T_{n}^{4}-T_{s}^{4}\right]=0$$
(II-135)

This can be rewritten as:

$$\frac{k_{n+1} + k_{n}}{2} \left[T_{n+1} - T_{n} \right] - \frac{k_{n} + k_{n-1}}{2} \left[T_{n} - T_{n-1} \right] + \frac{\rho_{n} I^{2} \triangle Z^{2}}{A^{2}} - \frac{T_{n} I \triangle Z}{2A} \left[\propto_{n+1} - \propto_{n-1} \right] - \frac{F P}{A} \left[T_{n}^{4} - T_{s}^{4} \right] = 0$$
 (II-136)

or:

Equation (II-137) forms the basis for the steady state calculation for the thermoelement.

The absorber and the radiator may be considered by rewriting Equation (II-36) for the steady state situation:

$$\frac{Q_{i,j}}{t_p} - \frac{\mathcal{O} F_{i,j}}{t_p r_j \Delta \Theta \Delta r} \left[T_{i,j}^4 - \overline{T'}^4 \right] + S_{i,j} - \mathcal{OG}_{O_{i,j}} T_{i,j}^4 +$$

$$+\frac{1}{r_{j}} \underbrace{\Delta \Theta \Delta r^{2}} \left\{ \Delta \Theta k_{i,j} \left[r_{j} - \frac{\Delta r}{2} \right] \left[T_{i,j-1} - T_{i,j} \right] + \right.$$

$$+ \Delta \Theta k_{i,j+1} \left[r_{j} + \frac{\Delta r}{2} \right] \left[T_{i,j+1} - T_{i,j} \right] +$$

$$+ k_{i,j} \underbrace{\frac{\Delta r^{2}}{r_{j}} \Delta \Theta} \left[T_{i+1,j} - T_{i,j} \right] + \underbrace{\frac{k_{i,j} \Delta r^{2}}{r_{j} \Delta \Theta}} \right.$$

$$\left[T_{i-1,j} - T_{i,j} \right] = 0 \qquad (II-138)$$

where the thermal conductivity behavior has been approximated. Now consider the following:

$$k_{i,j}$$
 $\left[\frac{r_j - \frac{\Delta r}{2}}{\Delta r}\right] \Delta \Theta t_p = Y_{r_{i,j}} = \text{radial conductance}$ (II-139)

$$k_{i,j+1} = \frac{\left[r_j + \frac{\Delta r}{2}\right] \Delta \Theta t_p}{\Delta r} = Y_{r_{i,j+1}} = \text{radial conductance}$$
 (II-140)

$$k_{i,j} = \frac{\Delta r t_p}{r_j \Delta \Theta} = Y_{\Theta i,j} = \text{angular conductance}$$
 (II-141)

$$r_j \triangle \Theta \triangle r = A_{i,j} = surface area$$
 (II-142)

Use of these equations allows Equation (II-138) to be rewritten as:

$$Q_{i,j} = \frac{\sigma_{i,j}}{A_{i,j}} \left[T_{i,j}^{4} - T^{i,j} \right] + S_{i,j} t_{p} - \sigma \epsilon_{oi,j} t_{p} T_{i,j}^{4} + \frac{1}{A_{i,j}} \left\{ Y_{r,i,j} \left[T_{i,j-1} - T_{i,j} \right] + Y_{r_{i,j+1}} (T_{i,j+1} - T_{i,j}) + \frac{1}{A_{i,j}} \right\} \right]$$

$$+ Y_{\Theta_{i+1,j}} \left[T_{i+1,j} - T_{i,j} \right] + Y_{\Theta_{i,j}} \left[T_{i-1,j} - T_{i,j} \right] = 0$$
(II-143)

or:

$$T_{i,j} = A_{i,j} \left[Q_{i,j} - \frac{\sigma F_{i,j}}{A_{i,j}} \left[T_{i,j}^{4} - T^{i,4} \right] + S_{i,j} t_{p} - \frac{\sigma F_{i,j}}{A_{i,j}} \left[T_{i,j}^{4} - T^{i,4} \right] + S_{i,j} t_{p} - \frac{\sigma F_{i,j}}{A_{i,j}} \left[Y_{r_{i,j}} - T_{i,j-1} + Y_{r_{i,j}+1} - T_{i,j+1} + Y_{\Theta_{i+1,j}} - T_{i,j} + Y_{\Theta_{i,j}} - T_{i-1,j} \right] \right] \left[Y_{r_{i,j}} + Y_{r_{i,j}+1} + Y_{\Theta_{i+1,j}} + Y_{\Theta_{i,j}} - T_{i-1,j} \right]$$

$$+ Y_{\Theta_{i+1,j}} + Y_{\Theta_{i,j}} - T_{i-1,j} - T_{i-1,j} - T_{i,j} - T_{i,j}$$

Equation (II-144) represents the form utilized for the steady state calculations of the absorber or the radiator temperatures. Although this equation has been derived by considering the difference equation which describes the plate behavior, it is virtually identical to the one obtained by the computer program from the automatically generated mesh arrangement. The only basic differences pertain to the determination of the conductance, which in the computer program, is obtained with a variable increment size in the radial and angular directions.

Investigation of Equations (II-137) and (II-144) show that the temperature which appears on the left side of the equation also appears on the right side to the fourth power. This is an unstable configuration if the term contributes to a significant degree to the solution. Normally, the contribution in Equation (II-137) is small and the effect is damped so that instability does not occur except in extreme circumstances. This is not the case when Equation (II-144) is applied to the radiator, although a problem probably will not occur in the absorber. The radiator rejects virtually all of the heat associated with the system to the surroundings via this temperature term to the fourth power. This represents an extremely unstable form. The instability will normally take the appearance of calculating a temperature on the left side which is too low, followed by the recalculation using the new value on the right side which gives a temperature on the left that is too high, followed again by one which

is too low, with divergence occurring very rapidly. Damping of this effect with this alternating type behavior is relatively easy to obtain by incorporating a fractional portion of the new value as computed by Equation (II-144) into the value which appears on the right side. This approach is utilized in the computer program as convergence to the correct answers is obtained.

It is not desirable to use strong damping during the entire calculation because this slows convergence to the correct answer. However, criteria still must be applied with this type of an equation so that stability is assured if it is not damped. The calculation approach utilized herein was to assume an allowed temperature change per iteration, and damp or extrapolate the results accordingly. The application of this process to the solutions may be obtained by considering:

$$T_{\text{new}} = T_{\text{old}} + f \left(T_{\text{old}}\right) + C T_{\text{old}}^{4}$$
 (II-145)

where:

Tnow = new value of temperature

Told = previous value of temperature f = a linear function of T 1, which

f = a linear function of Told which need not be defined here

C = a constant

which is the type of equation that must be handled. Since the temperature change per iteration is:

$$\Delta T = T_{new} - T_{old}$$
 (II-146)

Equation (II-145) becomes:

$$\Delta T = f (T_{old}) + C T_{old}^{4}$$
 (II-147)

Now consider that the calculation is to be forced so that a change of Δ T' is to occur per iteration, and that a number of equations of the type of (II-147) are applied to different nodes with some other node temperatures appearing on the right side. Then each of the Δ T_i (for the ith node) may be computed. If Δ T_{max} is the largest of the Δ T_i, then all of the Δ T_i are recalculated according to:

$$\Delta T_{i_{new}} = \Delta T_{i_{old}} \frac{\Delta T'}{\Delta T_{max}}$$
 (II-148)

Immediately, the new temperature for the next iteration may be obtained from:

$$T_{\text{new}_{i}} = T_{\text{old}_{i}} + \lambda T_{\text{inew}}$$
 (II-149)

This type of iteration will never converge to steady state answers because it automatically extrapolates so that the greatest temperature change is equal to A T'. Consequently, as the correct value is approached the forcing technique represented by Equations (II-148) and (II-149) is removed from the calculation procedure and a damping factor, as previously discussed, is applied. The point at which this occurs in the computer program is determined from the user's estimate of how many iterations will be required to reach steady state. This means that for most problems the user's estimate of the number of iterations will represent the minimum number of iterations the code will perform. It will virtually always require more iterations than estimated before it will automatically terminate the calculation procedure. If the termination occurs shortly after the estimated number of iterations has been reached, then the estimated value for future problems of that type should be reduced.

III. COMPUTER PROGRAM USE INSTRUCTIONS

A. Data Input

1. <u>Introduction</u>

Input for this program is flexible and for practical purposes need not follow any particular format. The location of the data on the cards, the number of items per card, the field length, etc., are entirely at the discretion of the user. Columns 1-72 may be used for input information. Other restrictions are that individual numbers must be separated by at least one blank, and one number may not be continued from one card to another. Extra blanks can be included as desired, since they will be ignored by the code. In general, however, the more compact the input the faster will be the data processing.

There is no designation between fixed point and floating point variables in the input. Hence, the following may all be used to read a "one" into the machine:

1

1.

1.0

1.0E+0

10.E-1

1.+0

10. -1

1.000000

+1

+10.-1

.1E+1

0.10E+1

+0.1E+1

0.1 + 1

etc.

The only restriction for inputting numbers, aside from number separation by blanks, is that numbers greater than approximately 32,000 must be specified in an exponential form.

This computer program is written in such a manner that it may be readily expanded. Therefore, the input sections of the program have been programmed so that more information can be provided than is presently utilized. The input description is written to be compatible with the existing

input routines, and where information that is provided in the input is not utilized, comments are made to that effect. This approach has been used so that as additions are made to the program, the use instructions may be kept up to date by merely deleting the necessary comments.

The input data are divided into major groups, which are in turn divided into small groups or individual items. Specification of the group (for example *3 for group 3) and a subgroup number defines the data to follow. Property tables may be read in any order, and the length of the table need not be given. The code will recognize the end of tables from the input. Groups and subgroups may be read in any desired order. When the end of input data is signaled, the code will perform a logical check to be sure that all of the necessary data have been read and that no conflicts have been specified. The data tables will be placed in the proper order and calculations begun.

Following problems may be investigated very easily when parametric investigations are to be performed. In these cases it is only necessary to read those data that are to be changed.

The panel may be defined by reading the overall dimensions of each of the constituents in terms of an (x, y) coordinate system oriented at one corner of the panel, and by reading thermoelement length. Specification of the number of divisions desired for computational purposes along each major dimension is sufficient for setting up a mesh. The code utilizes this information to generate a mesh approximately conforming to the input specifications.

2. Control Cards

Control cards are designated with a * in column one and a number in column two. The remainder of the card may be used for input information if desired. The following designations have been established:

Control Card	Meaning
*1	Descriptive Information
*2	Dimensions
*3	Thermoelement Properties
*4	Other Properties
*5	Heating Information
*6	Specifications
*7	Input complete - Partial input for another problem follows
*8	Input complete, complete input for another problem follows
*9	Input complete, no input follows

With the exception of *7 - *9 cards, the information may be read in any desired order. The *7 - *9 cards are used to signal the end of input for a problem and are therefore located last. The *1 - *6 cards may be read in any order and, if desired, partial information in one group may be read. This makes possible such input options as reading some *2 information, then some *5 information, then some more *2, etc. Further, if only one item is to be changed between problems, this may be done by reading only that one item. Other information previously read into the machine will be saved unchanged with the exception of *1 information.

It is never necessary to specify how much information is to be read before reading. Termination of a group of information will occur if a "Z" is inserted following the data. This can appear anywhere on a card, and can be followed on the same card by other numerical information. The first number following the Z must be a control number (as discussed under the * headings). A Z may not be used if the information to be read consists of a fixed number of words.

3. *1, Descriptive Information

Information read by the *1 card is printed as output at the beginning of the problem for which it is read and is then destroyed. The first card of this group must contain *1 in columns 1 and 2. Columns 3-72 may be used for any title information that is desired. Following cards do not need *1 in columns 1 and 2 although no harm will be done if this is included. In either case, only columns 3-72 will be printed as output. As many cards as desired may be read and printed in this manner.

It is not necessary to reread data already in the machine since this information is utilized automatically. (See *7 and *8 for further discussion of this point).

4. *2, Dimensions

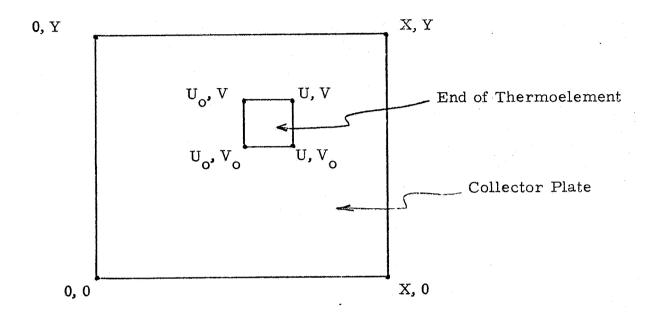
The first number read following *2 is a control number, which will be referred to as C throughout the remainder of this report. The value for C is then followed by the required information as specified in this section and summarized in Table 1. Another C may follow the presented information or a new control card may be used. The C's may be read in any desired order and as few C's as desired may be used, subject to the restriction that the dimensions must be fully described or the information must have been previously read.

TABLE III-1.* *2 CONTROL NUMBERS (C)

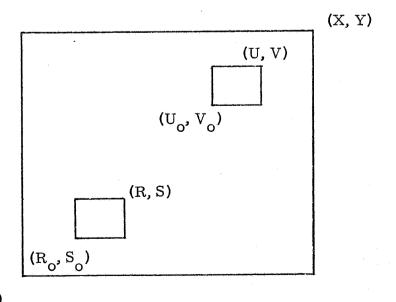
C Value	Data Required
1	Collector thickness
2	Collector dimensions X , Y and Z
3	Thermoelement dimensions Uo, Vo, U and V
4	Thermoelement dimensions Uo, Vo, U, V, Ro, So, R, S
5	Thermoelement length for non- segmented thermoelements
6	Number of segments followed by lengths for segmented elements
7	Thermoelement material designations
8	Radiator and edge dimensions
9	 Hot shoe thickness and material designations
10	Cold shoe thicknesses and material designations
11	Mesh information
12	Boundary information

^{*} The type 2 information used by the program in the present version consists of X and Y. Z must be read, but is not used for calculations. The options offered under the type 4 and type 6 input are not available, and C values corresponding to these should not be used. The type 8 information pertains to radiator edge thickness and edge width as well as radiator thickness. Only the radiator thickness is used in the calculations, although all 3 values must be provided for proper functioning of the input. The type 9 and type 10 information is used only to provide contact resistance data in the present version.

Two types of collector plates can be considered:

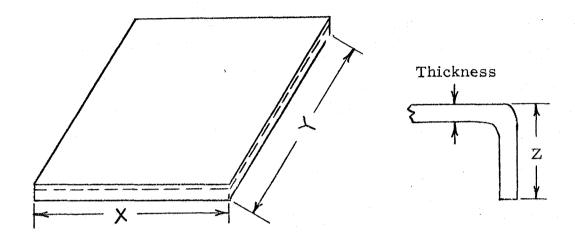


and a similar arrangement with two attached thermoelements rather than one. In the latter case the thermoelement corners will be specified by R and S as well as U and V. The meaing of R is the same as U, that of S the same as V, except we now describe two thermoelements:



(0, 0)

Only one piece of information will be read with a C=1 type input, the absorber (or hot side fin) thickness. Any dimensions may be used as long as a consistent set of data are given for all of the input. Type C=2 information reads the collector dimensions X, Y and Z (in that order) as shown on the following sketch:



Note that Z is not the thickness, but the total outside dimension of the plate edge that has been bent over.

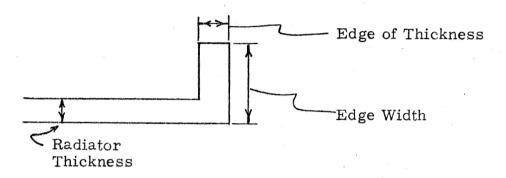
Type C=3 and 4 information refers to the thermoelement dimensions as previously discussed. This information will be read in the order presented under the headings in Table III-1. If for some reason both 3 and 4 type information were read, an error would result and this case would be skipped. Further, if type 3 information had been read for a previous problem, and type 4 information read for a present problem, then sufficient additional information would be required that the problem were fully described or the case would be refused. This will be discussed further at the end of this subsection.

Type C=5 information requires the thermoelement length for non-segmented thermoelements. If C=3 information has been (or is to be) read, one length is required; if C=4, two lengths, the first for the UV T/E, the second the RS T/E. The end of this information must be signaled by a "Z" since the code "doesn't know" how many numbers to read.

Type C=6 information is used if segmented thermoelements are to be used. The first number read is the number of segments in the UV system (10 or less are allowed) and this is followed by the segment lengths. If information for an RS system is required, this is read next in the same manner. The end of this information must be signaled by a "Z". The segments should be read beginning at the hot end.

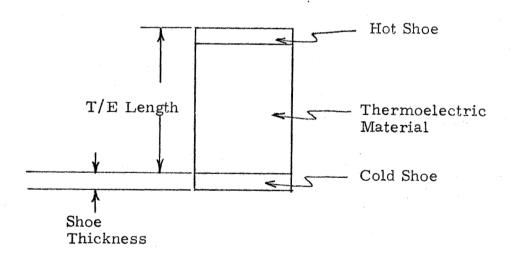
Type C=7 are thermoelement material designations read in the same order as for type 6. These material designations are numbers referring to properties read using *3 input and, therefore, specify the thermoelement material. A "Z" must terminate this information.

Type C=8 input is three numbers, the radiator thickness, the edge width, and the edge thickness.



These are read in the presented order.

Each thermoelement or thermoelement segment is considered to have the following form:



C=9 is used to read in the hot shoe thickness followed by the hot shoe material designation. If multiple thermoelements or segments are used, the readings are repeated in the order read in C=7. All thicknesses are read first, and then all material numbers. If R-S as well as U-V thermoelements are used, the thicknesses for the U-V T/E's are read, then for the R-S T/E's. The material designations are then read in the same order. C=10 does the same thing for the cold shoes. Note that zero thickness shoes are allowed, which is the same as no shoe. A material still must be specified, however. The end of C=9 and of C=10 information must be specified by using a "Z".

Mesh information is given through the use of C=11. The number of mesh points are read for each of the dimensions in the following order:

- (1) Each collector side starting at (0,0) and proceeding in a counterclockwise direction.
- (2) Each collector side starting at (Uo, Vo) and proceeding as before.
- (3) Repeat Item 2 (above) for R S if used, otherwise this is ignored.
- (4) The number of mesh points in the thermoelements reading first the UV T/E and then the R S T/E. If segmented T/E's are used, begin at the hot end and work toward the cold end reading the number of mesh points per segment for the UV T/E. Repeat for the R/S T/E if one is used.

These data are used as guides in setting up the mesh for calculation purposes. They will seldom be used exactly as specified. The total number of mesh points must be less than 1000 (the collector and radiator have the same number of points). The end of this information must be indicated by a "Z".

The C=12 information pertains to whether the edges are exposed or "see" other flat plate packages and hence are insulated. Ones should be read if the edges are exposed, zeroes if insulated. The edge should be traced starting at point (0,0) and going in a counterclockwise direction.

A typical set of information under *2 could be read using the following cards*:

*2 1 .002 2 .5394 .5394 .028 3 .2452 .2942 .2942 5 .0984Z7 1 Z 8 .0025 .007 .028 .005 9 .0055 2 Z 10 .0055 2 Z 11 4 4 4 4 4 4 4 4 6 Z 12 0 0 0 0

Although the entire *2 information is shown in one place, if desired it could have been scattered throughout the input. Further, the values of C can be taken in any desired order, rather than the order taken here. Note that blanks need not be left between Z and a number, but this can be done. In general, the only restriction on the order or quantity of data is that each C group must be complete. If partial input is required and the remainder of the information was read for a previous problem, only the C groups that are to be changed need be read. However, if the change in the C group changes other requirements, then these must be changed as well. An example of this would be a change from one T/E to two. Then new dimensional, material, mesh information, etc. would all be required.

5. *3, Thermoelectric Material Properties

Allowance is made for up to 6 (inclusive) tables of thermoelectric properties. Control numbers, C, are used to indicate the table number (1, 2, 3, ..., 6) and are followed by absolute temperature, seebeck coefficient, thermal

^{*} The sample problem is based on information given in MELPAR and the dimensions are given in inches. Any consistent set of dimensions may be used.

conductivity, electrical resistivity, heat capacity, density, and relative emissivity, in the presented order. To read data, first read a control number, then a temperature, then the properties at that temperature, then another temperature, more properties, etc. The end of a table must be indicated by a "Z". This can be followed by another control number if desired, in which case another table can be read. The maximum total number of temperatures that can be read is 200; the minimum number is 3. Linear interpolation is used in the tables.

The temperatures can be read in any desired order, and it is not necessary to number the tables consecutively. If data for one table are to be changed, only that one table need be reread, the others will be unaffected. The same table number may not be read twice during the same reading, but a table number used for a previous problem can be reused for a present problem. In this case the previous table is eliminated.

6. *4, Other Properties

As in the *3 tables, control numbers are utilized to indicate the table (or material) number. The following designations are used:

С	Meaning
7 - 12 13 - 14 15 - 16	Shoe Information Absorber Information Radiator (Backup Plate) Information

Information read by C=7 - 12 is a temperature (absolute) and values for thermal conductivity, heat capacity, density, electrical resistivity, and contact resistance (in that order) corresponding to that temperature. "Z's" must be used to indicate the end of each table.

The C=13 - 16 information is identical to C=7 - 12, except a value for relative absorptivity and two values for relative emissivity are read following the electrical value and no contact resistance is read. The relative absorptivity and the $\underline{\text{first}}$ relative emissivity will be applied to the outside (exposed) surface, the second relative emissivity to the internal surface.

Other comments made in the *3 input data section are applicable in *4 data input.

7. *5, Heating Information

This information pertains to the environment as "seen" by the thermoelectric power supply. The following designations for control numbers are used:

<u>C</u>	<u>Meaning</u>
1	Solar constant (heat flux)
2	Planet Reflectivity Constant (albedo)
3	Stefan Boltzmann Constant
4	Time

<u>C</u>	Meaning
5	Mean Planet Temperature as "seen" by the plate
6	Planet view factor for radiant heat transfer from the planet to the absorber
7	Planet view factor for radiant heat transfer from the planet to the radiator
8	Planet view factor for the planet albedo to the absorber
9	Planet view factor for the planet albedo to the radiator
10	Solar angle (Radians)
11	Function Calculation

The first three C's are single-valued constants, and as such need be read only once. The end of these numbers need not be signaled by using a "Z". The other C's are used to designate groups, and the end of each group of numbers must be signaled by a "Z".

If only one value of time (C=4 information) is read, and that time is zero, then a steady state problem will be assumed. If nonzero values are read, then at least three values must be read, and they must be read in increasing order. The lowest value may be zero. Up to 100 (inclusive) values may be read.

The C=5-10 information corresponds to the values of time (C=4). If a constant is desired, only one value need be read. Otherwise, the same number of values as used for time (C=4) must be read. The meaning of these numbers can be obtained by considering the following brief discussion.

The solar heat flux absorbed by a flat surface is given by:

$$q = S \cos(\delta) \approx 0 \leq \delta < \frac{1}{2}$$

$$= 0 \qquad \qquad \frac{1}{2} \leq \delta \leq 1$$
(III-1)

where:

q = heat flux
S = solar constant

\$ = angle measure from a normal to the surface

In this analysis, $0 \le \frac{1}{2}$ will be taken to mean that solar heat is impinging on the collector; $\frac{\pi}{2} \leftarrow \xi = \pi$ will mean it is impinging on the radiator, and $\xi = \frac{\pi}{2}$ means that no solar heat is being absorbed. The heat flux absorbed by the thermoelectric system from a planet is given by:

$$q = \sigma F_1 T^4 \in (III-2)$$

where:

T = Stefan Boltzmann Constant

F₁ = Radiation view factor

Γ = average planet temperature as seen by the thermoelectric system

The albedo heat flux is given by:

$$q = SRF_2 \sim (III-3)$$

where:

R = Reflectivity Constant (albedo)

Much of this information can be calculated if orbital parameters are defined, and provision is made to do this if desired by using the C=11 input. In this case, subroutine HEAT (TIME, T, FIC, FIR, F2C, F2R, DELTA) will be called.*

8. *6, Other Data

Information read using the *6 designation has the following meanings:

<u>C</u>	Meaning
1	Load resistance
2	Symmetry designation
3	Transient problem investigation time
4	Minimum allowable time increment
5	Maximum allowable number of iterations
6	Maximum allowable temperature change per iteration
7	Steady state convergence factor
8	Frequency of long print-out in transient calculations

^{*} The arguments are the C=4 - 10 variables, and each is a 100 number array. These data should be placed in the array in the same manner as though they were read, except the use of "Z's" is not permitted. Zeros must be placed in all portions of the array not specifically used. The same number of values as times must be used. This subroutine is not presently available, and a dummy subroutine of the same name has been included in the deck.

	<u>C</u>	Meaning
	9	Frequency of short print-out in transient calculations
	10	Mesh specification: If zero or negative, the mesh calculations are to be performed; if equal to one, the mesh calculations are to be skipped.
	11	Node map generation designation: If zero, no map is generated in the print-out; if one, a map is generated.
	12	Transient-steady state designation: If one, a steady state problem; if zero, a transient problem.
	13	Convergence criterion for steady state calculations
	14	Frequency of long print-out in terms of number of iterations
	15	Frequency of short print-out in terms of number of iterations
	16	Estimated number of iterations required for convergence in steady state calculations
•	17	Collector material number
	18	Radiator material number
	19	Not assigned
	20	System initial temperature

Each of these items is discussed in more detail, where required, in the following paragraphs.

The load resistance, specified by a control number equal to one, is that resistance "seen" by the portion of the solar flat plate being simulated by the computer program.

A control number of two refers to a symmetry designation. Proper use of this term will result in drastic decreases in computation time and a saving of close to a factor of eight can be obtained in many cases. The symmetry designation number is the number of nodes in a repeating portion of the solar flat plate. To see exactly what is meant by this statement, consider Figure III-1. This figure illustrates a completely symmetrical solar flat plate with the thermoelement located in the center and with six nodes specified on each of the four sides. Each of these "rays" is shown in the figure. Specification of a symmetry number of 12 with this configuration would cause the computer program to calculate temperatures beginning at line AO and continuing counterclockwise to line DO. No calculations would be performed for temperatures from line DO counterclockwise to line AO since they would be a mirror image of the previously calculated temperature. Any time a detailed print-out was required, the temperatures from the calculated portion would be reproduced in the uncalculated portion and then all nodal points would be represented in the output.

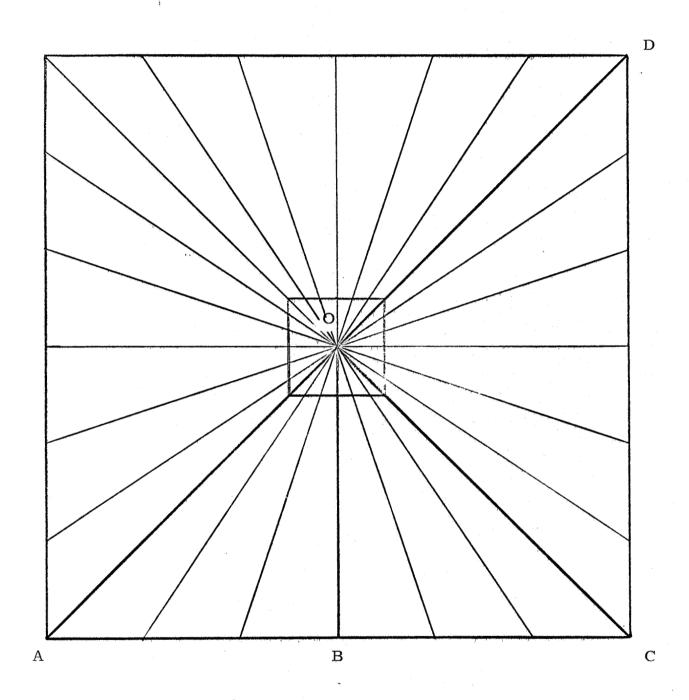


Figure III-1. Illustration of Symmetry Designation Number

Specification of a symmetry number of six would cause calculations to be performed beginning at line AO and progressing in a counterclockwise direction to line CO. No other calculations would be performed, and a detailed print-out would be obtained in a manner similar to that discussed for a symmetry number of 12. Specification of a symmetry number of three would cause calculations to begin at line AO and progress in a counterclockwise direction to line BO. This latter specification would result in a factor of eight less calculations than if no symmetry number were defined or if a symmetry number of 24 were read. The advantage of taking into account the symmetry of the solar flat plate immediately becomes apparent.

Note that a requirement for a symmetrical designation is that the lines of symmetry correspond to nodal separation lines as set up by the computer program. For example, if the number of nodes between points A and C were specified as five rather than six, and similar designations were made for the other three sides, a symmetry specification of five or ten could be made. In this case, a factor of four or two, respectively, decrease in the number of calculations would be obtained. A factor of eight decrease in the number of calculations would be impossible with this designation because integer numbers must be specified, and a specification of 2.5 would be required to take full advantage of the symmetry of the figure, an impossible arrangement.

Care should be taken in the selection of the symmetry number since if a designation is given which is inconsistent with the figure generated by the computer program, the symmetry specification will be neglected and calculations will be performed for all nodes in the solar flat plate. This obviously could cause a considerable increase in running time over that expected with a correct symmetry designation.

A control number of three specifies the maximum time which is to be simulated for investigation of a transient calculation. The problem is terminated when this simulated time has been reached by the computer program. This particular number is not used if a steady state type of calculation has been specified.

A control number of four can be used to represent the minimum time step that is allowable for a transient calculation. The problem will be rejected if a lower time step is required for calculation purposes. A zero is allowable as an input for this number if desired, and a zero will be used if no number is read.

A control number of five defines the maximum number of iterations which will be permitted during a run. If this number is exceeded, the problem will be terminated.

The maximum temperature change per iteration that will be allowed is specified with a control number of six. The calculations will be performed for both the transient and the steady state utilizing this value. In the transient calculation, the time increment will be selected so that the maximum change in temperature is approximately the input value. In the steady state, this value will be the allowable change per iteration, and an extrapolation factor will be selected so that this value is attained (see also the input with a control number of 16).

Input with a control number of seven is the convergence factor utilized for a steady state calculation. A value between 0.5 and 0.8 is recommended (see also the input under a control number of 16).

A control number of eight is used to specify the time separation between detailed temperature print-outs. The temperatures which are outputted will be presented as a function of node number, and ordinarily a node map will be required to interpret the results. This number is ignored for steady state calculations.

The time separation between concise print-outs is specified with a control number of nine. A concise print-out consists of the time, time increment, iteration number, electrical power output, electrical current, the error in the heat balance, the overall conversion efficiency based upon the heat received by the absorber and the electrical output, the hot junction temperature, the cold junction temperature, the average radiator temperature, and the average absorber temperature. A concise print-out is obtained automatically whenever a detailed print-out is output. A long and short print-out is given at the termination of each problem. Specifications with a control number of nine are ignored if steady state calculations are being performed.

A control number of ten is a flag which defines whether the mesh is to be set up or not. The mesh must be calculated if any input has been used in a problem which can change the volume of a node, the separation of one node from another, or the node connection arrangements. If a mesh calculation is specified by reading a zero or negative number with the control number of ten, the temperature specified as an initial condition (*6 20) is used to set the temperature of all of the nodes. If the mesh is not to be calculated, which occurs with a specification of one, then the node temperatures which were previously used represent the starting point of the calculations.

Changes in the following input designations do not require the generation of a new mesh: *1, *2 5, *2 7, *2 9, *2 10, *3, *4, *5, *6 1, *6 2, *6 3, *6 4, *6 5, *6 6, *6 7, *6 8, *6 9, *6 12, *6 13, *6 14, *6 15, *6 16, *6 17, *6 18, and *7. All other input specifications require that a new mesh be generated.

A control number of 11 specifies whether a print-out of the node map is desired or not. If a value of zero is read, no map will be detailed. If a value of one is input, then a complete map will be generated. This map will consist of a scale sketch generated by the computer using the output printer which illustrates the outline of the absorber, and each of the node centers will be located within this sketch to within roughly one part in one hundred. Co-ordinate numbers will be generated along the sides of this map so that each of the nodes may be referred to by two coordinate numbers. A table will be generated which lists the node numbers corresponding to each of the node centers in terms of the reference numbers generated on the map. The node representations for the radiator will not be generated in a map since the map would be identical; however, the complete representation of these in tabular form will be generated.

The data read using a control number of 13 will be utilized by the computer program to determine when convergence has been achieved in steady state calculations. This number should be the temperature change per iteration that it is desired to attain during steady state calculations. When a maximum temperature change during an iteration has resulted which is less than this number, the problem will be terminated. (Note that in setting up the print specification requirements, final answers are always given upon problem termination.) The number input using a control number of 13 is ignored if a transient calculation is specified.

A control number of 14 causes detailed print-out of results to occur for both the steady state and transient calculations. The value read is the number of iterations between each detailed print-out. If detailed print-outs as a function of iterations are not desired, a large number should be used.

The information obtained by the program using a control number of 15 is identical to that previously presented for 14, except in this case the concise print-out is to be described.

A control number of 16 causes an estimate of the number of steps required for convergence in the steady state to be read. This estimate is used by the computer program during the calculation process. For all calculations performed prior to reaching the number of iteration steps given in this estimate, a change in temperature per iteration as specified using a control number of six is forced. After this estimate has been reached, the temperature change is multiplied by the factor input using a control number of seven in computing temperature changes per iteration. This means that the steady state calculation procedure cannot terminate until after the number of iterations input under the control number 16 has been exceeded. However, the convergence rate will be forced prior to this number being reached. The effectiveness of this "forcing" decreases with the number of iterations performed.

A control number of 17 refers to the material specified for the collector, and the one under a control number of 18 refers to the radiator material. These values are the table numbers which were input using the *4 input.

The initial temperature of the entire generator should be input using a control number of 20. Absolute values of temperature must be used, but other than this restriction, any units desired can be selected, provided consistency is used in all input.

9. *7, *8, *9 Information

These control cards signal the end of input for a particular problem. If *7 is used, calculations will be performed for the data read into the machine. When the required computations have been completed, control will be transferred to read further input information for a new problem. The input for the new problem need contain only those items that have been changed from the previous calculation. All of the previously read information is preserved unless replaced by new input.

The use of a *8 control card will cause behavior similar to the *7 card, except the input for the new problem must be complete. None of the previously read information will be available for a new problem.

The *9 card signals that no input data follows. The required calculations will be performed, and then control will be transferred back to the computer systems tape and the run will be terminated.

B. PROGRAM DESCRIPTION

1. Introduction

This computer program is written for an IBM 7094 which has approximately 32,000 words of storage. Roughly 20,000 words are provided at all times within the core for storage of variables so that the lengthy input-output of data required for calculations is not necessary except to obtain initial information or to provide answers. However, the computer program requires much more memory than the remaining 12,000 words. For this reason, it has been broken into a number of links. The main control of the computation process and those subroutines which require extensive use are always left in the core of the machine. The other subroutines are brought into the core as necessary. The arrangement of subroutines is such that a subroutine need be brought into the core only once for each problem that is to be investigated.

The names of the subroutines and the link to which they are assigned are shown in Table III-2. The overlay construction is shown in Figure III-2.

2. Main Program

The main program serves basically as a calling sequence and controller for all subroutines. It first causes all storage locations used by this program to be cleared. It then causes the input data routines to be selected, selects the routines which process the data and store it in the proper locations, sets up the routines which automatically generate the mesh, and then calls in the basic calculation routine. When calculations have been completed on one problem, it either selects input for a new problem or causes the machine to be returned to the system control.

3. Subroutine LENGTH

This is a very short subroutine which merely computes the straight line distance between two points when the x and y coordinates are given.

4. Subroutine INTER

This subroutine is used to compute the (x, y) coordinates of the point of intersection of two straight lines. The straight lines are described by giving the (x, y) coordinates of two points on each of the lines.

TABLE III-2. COMPUTER PROGRAM OVERLAY CONSTRUCTION

Subroutine Name			Link	Number
MAIN				0
POINT	. •			1
LENGTH				1
INTER				1
AREA				1
CHECK		*		2
PRO-3				3
PRO-5		.*		4
HEAT				4
PRO-4				5
PRO-6				6
PRO-2				6
NUMBER				7
READIT				7
UNPAK				7
PACK				7
SQUASH				7
MESH				8
MESHA				9
MESHB				10
MESHC			•	10
FPMAP				1.1
PROP	•			12
CALCS				13
CALCT				13

Γ	,	PROP (11) CALCT (13)
	MESH E (9)	PRO CALCS (12) CAL
	MESH (7)	CALC
The state of the s	(9) (9) (9) (9)	
A CALL THE RESERVE THE PROPERTY OF THE PROPERT	PRO6 PRO2 NUMBER READIT UNPACK PACK	
	MESH A (8) PRO4 (5)	
A THE TAX A SECTION OF THE PARTY OF THE PART	MES HEAT (4)	
	PRO 3 (3)	
The second secon	(1) (1) (1) (2) (2) (2) (2) (2) (2) (10)	
Section 1975 - 1976 - 1978 (Section and Bedeling and Section 1979)	POINT LENGTH INTER AREA FLOG FXPF FXPF FXPF FXPF FXPF FXPF FXPF	3

MAIN (0)

Figure III-2. Overlay Construction

5. Subroutine POINT

The basic calculations are set up using a cylindrical coordinate system. However, it is necessary to relate this to the (x,y) coordinate system which is utilized in providing input to the program. This subroutine takes the radius and angular information being utilized in the program and converts to Cartesian coordinates.

6. Subroutine AREA

Each of the nodes used for calculation purposes is considered as being located at the centroid of its assigned area. This latter value is computed by considering smaller areas of triangular cross section. Subroutine AREA computes the centroid locations in Cartesian coordinates and the surface area from the Cartesian coordinates which describe the three corners of the triangle.

7. Subroutine HEAT

As explained in the input description section, subroutine HEAT is not presently available. However, a dummy subroutine is presently provided. If it is desired in the future to provide automatic calculation of the surroundings as "seen" by the solar flat plate power supply, a suitable subroutine may be added at this point. The actual location of this subroutine in the link structure is relatively unimportant since it will only be called once for each problem. The data it provides is utilized in exactly the same manner as though input data were provided. The calculation process is based upon a linear interpolation of this information.

8. Subroutine NUMBER

This subroutine generates integer or decimal numbers from the components as read by the machine using subroutine READIT. An integer number furnished to this subroutine will consist of only two portions, a sign and a significant figure. Subroutine NUMBER multiplies these two portions, and then stores the result in storage allocations corresponding to the type 2, 3, 4, 5, or 6 input.

A decimal or floating point number consists of several portions. The exponent consists of a sign and a significant figure portion, and the significant figure portions consist of a sign, the integer (that portion of the number to the left of the decimal point), and the significant figures which occur to the right of the decimal point. Subroutine NUMBER compiles these various pieces to form the completed number and then stores them in the proper location as previously described for an integer number.

9. Subroutine READIT

All input to this program is by A-mode conversion. This enables the program to read any recognized FORTRAN character. Subroutine READIT causes these data to be read and then processes the information.

The initial character on an input card is first checked to see if it has an asterisk, and if an asterisk is found, the character is column 2 is shifted to the right-most position in its storage location so that the type of

control card may be determined. If an illegal character is found in column 2, the entire card is printed out with a comment to the effect that an illegal control card was found, and the program is removed from the computer. If the first card of data read is found not to be a control card, it is assumed that the control card is missing and the problem will be refused. If a legitimate control card is found, it is analyzed to see if this is information pertaining to input data, or if the information defines the end of a problem. If an end of problem is found, control is transferred back to the MAIN PROGRAM for the beginning of the processing of the information which has been read and stored in the machine. If the control card indicates that data are to be processed, then the required action is taken.

If the card read is a comment card (*1), then the first two columns of the card are considered to be blank, and the remainder of the card is printed as output. If the card is determined to contain numerical information, then that information is processed. Each of the allowed characters - BLANK, -, +, ·, E, Z, 0, or 1 through 9 - is checked and appropriate action is taken.

Construction of a number first begins with a sign indication, or if no sign indication is found, with an integer portion. If a BLANK is encountered during the compilation of the integer, the end of the number is assumed, and subroutine NUMBER is called. Any other allowed character will either be a single digit integer, a decimal point, or exponent type information. An integer is treated by simply shifting the previous integer to the left and adding the new one. A decimal point merely sets a flag so that further integers are stored in a different location and are treated as the significant figure portion to the right of the decimal point. Any of several characters may indicate an exponent and if this is found, a flag is set. Any further information obtained after the flag is set, but before a BLANK is found, is incorporated into the exponential portion of the number prior to calling subroutine NUMBER which processes the information and stores it in the right location.

If at any time an illegal character or an unallowed number is found, or a return is received from subroutine NUMBER with an error designation, then a check is made to determine if any further problems remain. If no problems remain, the program is automatically removed from the computer. If further problems remain, then a flag is set and subroutine READIT transfers control back to the MAIN PROGRAM. The MAIN PROGRAM is caused to clear the portions of the machine allotted for data storage, set a flag, and reenter subroutine READIT. This institutes a search process of the remaining data until a complete new problem is found. At this point, analysis will proceed.

10. Subroutine UNPAK

One of the basic ground rules under which this computer program was written was that the input-output of information from the computer core would be limited to input data and output answers. The initial processing of input information required the storage of a large number of one or two digit integer numbers. This type of information requires only a few bits in a word, and the remainder of the word is not used. Consequently, when a shortage of core storage was encountered, the integer numbers were compressed so that eight were stored in a single word location in the IBM 7094 memory. Subroutine PACK causes this compression of the integer numbers to take place. Subroutine UNPAK causes the inverse to occur.

These subroutines require a small MAP routine (the equivalent of the FORTRAN IV machine language). The two entry points of this machine language portion are titled SQUASH and SPREAD. Their functions are self-explanatory.

11. Subroutine CHECK

There is no way of determining the difference between a minus zero and a plus zero using FORTRAN IV. Consequently, a small MAP subroutine was written which provides a solution to the problem.

12. Subroutine PRO-2

This subroutine is called after all of the information has been processed by READIT. This particular routine processes all of the information that has been input using the *2 control. The subroutine causes all of the data to be processed and stored in the necessary memory allocations which have been assigned for each of the variables. All of the input data are cross-checked to be certain that sufficient data have been provided and that contradictory or inconsistent data have been excluded. The first of several checks on the number of mesh points specified is also made in this subroutine. If an error is found, a flag is set and control is returned to the MAIN PROGRAM for processing of the remaining information to determine if another problem remains which can be attempted.

13. Subroutine PRO-3

The function of this subroutine is quite similar to PRO-2 except that the type of information to be stored is different. This subroutine first causes all of the thermoelectric information that has been previously stored in the computer memory to be moved to a different location for temporary storage. The new information is then processed and all of the property data are stored in the designated locations. It is possible at this point that the data could have been input to the computer in a nonascending temperature order, and consequently the data are immediately reprocessed so that all information is in the order of increasing temperature. After this has been done, checks are made for specifications of duplicate table numbers on the input data. If none are found, then the information which was saved from previous problems is merged with the new information so that a complete set of data are available. If, during this merge process, any duplicate tables are encountered, the old tables are eliminated.

Once all of the tabular information has been compiled and sorted, a check is made of the information which will be required during the calculation process. If it is found that information is going to be requested which is unavailable, a comment will be made to this effect and an error return procedure will be instigated. Otherwise, notations are set up so that the information can be used during the calculation process.

14. Subroutine PRO-4

This calculation process is virtually identical to that previously discussed in subroutine PRO-3. The only differences are slight perturbations in the material which is to be stored and in the references which are set up so that the data can be later utilized.

15. Subroutine PRO-5

This subroutine is relatively straightforward and short, and serves to merely store the input data in the proper locations. It also contains the calling sequence for subroutine HEAT.

16. Subroutine PRO-6

This subroutine processes the remaining data which are necessary for the utilization of the computer program. In each case, each piece of data information is preceded by a control number which is then utilized in subroutine PRO-6 for storage information purposes.

17. Subroutine MESH

This subroutine contains the beginning of the automatic mesh generation procedure. The first items which are computed are the angles interconnecting the center of the thermoelement with its corners. and the center of the thermoelement with the corners of the attached plate. The number of points specified for the edges of the plate and thermoelement are next investigated to determine the more stringent requirements. When this has been obtained, the previously calculated angles are divided up into small segments. The segments are next smoothed by an iterative process so that the accuracy of the calculations will be improved.

Once these calculations have been done, it is possible to compute the radii corresponding to each of the angular segments at the intersection of the thermoelement and the plate, and at the plate edge. These are stored at the proper locations and then the angular segments are integrated to provide the angle between a line connecting the center of the thermoelement with the Cartesian coordinate point (0,0), and the angular segment. When this calculation has been completed, and an average angular segment size has been determined for calculation purposes, control is transferred back to the MAIN PROGRAM which then immediately calls subroutine MESHA.

18. Subroutine MESHA

This subroutine continues the calculations which were begun in subroutine MESH. It first causes the stored locations assigned for the areas, the centroids, and the inside and back length to be cleared. It then selects the first node and assigns a trapezoid to the node. The Cartesian coordinates of each of the trapezoid corners are assigned and each of the corners is investigated to see whether it lies within the plate, within the portion of the plate assigned to the thermoelement, or outside of the plate. An index is set up as each of these determinations is made. This index is next used with a computed "GO TO" statement so that the proper breakdown of the trapezoid into triangles for calculation of area and centroids is obtained. (See Section II-C,)

During this calculation process, several nodes will be obtained which are totally within the area assigned to the thermoelement, and others will be obtained which are totally outside of the plate. Suitable indices are set up so that these nodes are not referred to or incorporated into the calculation process. Further, several logical calculations are made to assure that the memory allocation assigned for the storage of node information is not exceeded.

When the calculations in this subroutine have been satisfactorily completed, transfer is made back to the MAIN PROGRAM which then calls in subroutine MESHB.

19. Subroutine MESHB

A number of very small nodes can be readily obtained during the previously described calculation process. These nodes, which can result from portions of the trapezoid either being within the thermoelement or outside of the plate, will contribute nothing to the calculation, and indeed could considerably slow the calculations. Consequently, they are combined in this subroutine with adjoining nodes in such a manner that accuracy is for practical purposes not compromised. This joining process is made by comparing the size of a node with its nearest neighbor. If a factor of four difference in the size is obtained, and certain other criteria are also satisfied, then the node is combined with its neighbor. This combination process consists of the addition of the areas, and the weighted relocation of the node centroid in the Cartesian coordinate system. Information must also be incorporated for the logical calculation of the cross sectional area common to one node and its neighbors.

When this information has been compiled, transfer is made back to the MAIN PROGRAM which then calls in subroutine MESHC.

20. Subroutine MESHC

This subroutine computes the area-to-length ratios necessary for the future calculation of conductances between the various nodes. It also sets up the initial mesh temperatures and finishes setting up the boundary information which is required.

21. Subroutine FPMAP

This subroutine generates a scaled map of the mesh arrangement which has been generated by the computer program. The map is caused to be printed on output paper to a precision of approximately one part in a hundred. Tabular information which will later enable the user to relate temperatures to specific positions is also presented.

22. Subroutine PROP

This subroutine provides linear interpolation of all input data which is either a function of temperature or a function of time. It is utilized during the calculation process so that the physical properties of the absorber, radiator, and thermoelement are treated as temperature dependent variables. Transient characteristics as generated by subroutine HEAT or as described in the input are also processed in this subroutine.

23. Subroutine CALCS

This subroutine constitutes the main steady state calculation process of the program and is the portion of the program where most of the steady state calculation time is expended. It is broken into three portions: mesh property evaluation, steady state calculation, and print-out of results.

The properties of the absorber, radiator, and thermoelements are determined by calling subroutine PROP. These properties are utilized to compute conductances between each node and its interconnected nodes, the heat capacity of the node, and the surroundings information (such as solar input, albedo, planet input, and heat rejection from the exposed surfaces). When these data have been computed, a number of other characteristics which will be necessary are computed and stored (such as temperature to the fourth power).

The calculation is begun by first considering the hot junction node. The conductance for this node to all of the surrounding nodes is obtained by integrating with respect to angle through 360° (or less if a symmetry specification has been incorporated). The conductance to the thermoelement is next computed, and the various effects such as Peltier cooling and contact resistance heating are included. The calculation of a new temperature immediately follows.

The calculation of the cold end node temperature is virtually identical. Once this has been computed, the thermoelement calculations are made on a node-by-node basis, and then the absorber calculations are made. The same calculations are utilized for the absorber as for the radiator, and the radiator is computed by merely resetting some indices and using the same equations.

Once new temperatures have been obtained, they are multiplied by the extrapolation factor and checks are made to determine whether further calculations must be performed.

The generation of print-out information is relatively straightforward and will not be discussed in detail.

24. Subroutine CALCT

This subroutine performs the transient calculations for the program, and most of the calculation time for this type of problem will be spent here. The routine is very similar to subroutine CALCS, discussed in the previous subsection, and the only basic difference is the addition of heat capacity and time terms to the steady state calculation. The calculation process is virtually identical and need not be discussed further.

IV. CALCULATIONS PERFORMED USING THE PROGRAM

A. Sample Problem

The input data for a sample program and the resulting computer output are presented in the following pages. Figure IV-1 shows sample input data for the calculation of the characteristics of a repeating section of the present solar flat plate configuration. This specific problem did not contain a request for a map of the array. The array which would have been generated is shown in Figure IV-2 which was obtained from a previous computer run. Figure IV-3 gives map coordinates, x - y coordinates, and the node number. Also shown are the summary results when convergence was obtained. For this steady state problem, the time and time increment are meaningless. The iteration number indicates that it took 2456 iterations for the specified convergence to be obtained. The power output from the repeating section was 0.00566 watts, the current was 0.373 amps, and the fractional error in the answer obtained by comparing with an overall heat balance was 0.00259. The overall efficiency based upon the heat absorbed by the panel is 2.63 percent. The hot junction of temperature computed was 922°R, and the cold junction temperature 636°R. These compare to an average absorber temperature of 9370R and an average radiator temperature of 624°R. These average temperatures were obtained by a weighting of temperature to the fourth power so that the true heat rejection characteristics of the surfaces are obtained. The computer printout which gives the detailed temperature distribution is also shown in Figure IV-3. The location of each of the presented temperatures may be obtained by referring to the previously generated node numbers.

Similar results are obtained if the node specification is changed to three or four nodes on a side. The node map for a three node specification is shown in Figure IV-4 and Table IV-1, that for a four node specification in Figure IV-5 and Table IV-2.

B. Comparison with Previous Calculations

Fuschillo* has presented an analysis of the Solar Flat Plate Generator using manual calculation techniques. Since this is the most complete analysis which has been published, it will be used as a basis for comparison.

^{*}Fuschillo, N., R. Gibson, F.K. Eggleston and J. Epstein, "Flat Plate Solar Thermoelectric Generator for Near-Earth Orbits," Advanced Energy Conversion, Vol. 6, pp. 103-125, 1966.

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1000 1.06-4 1.56E-2 .996E-3 35.5 .277 .1
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Figure IV-1. Sample Input

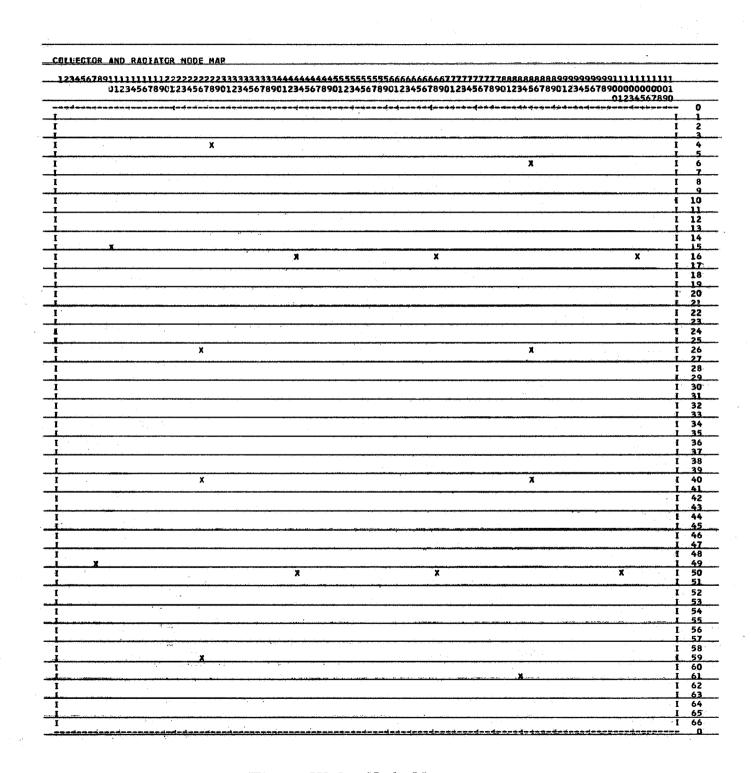


Figure IV-2. Node Map

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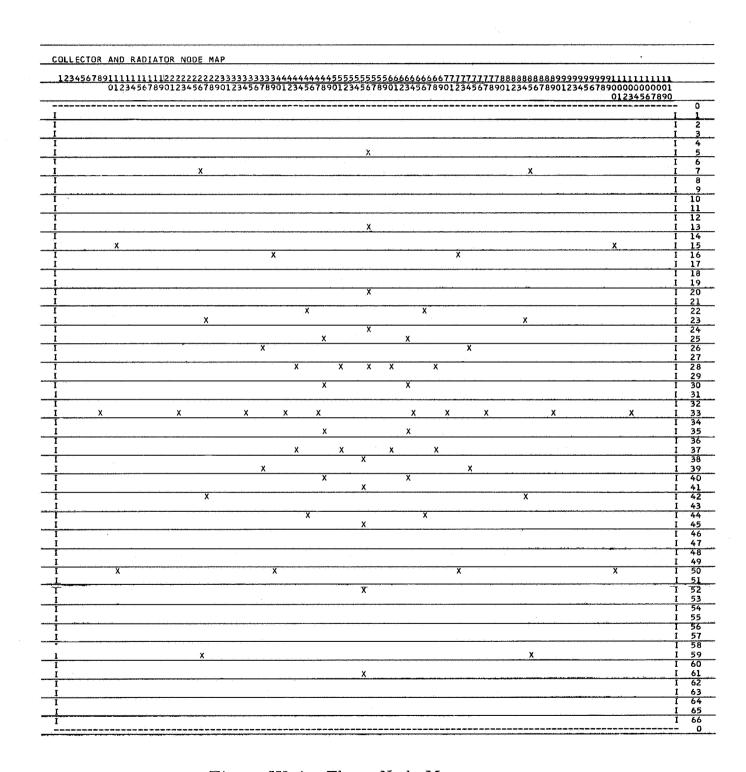


Figure IV-4. Three Node Map

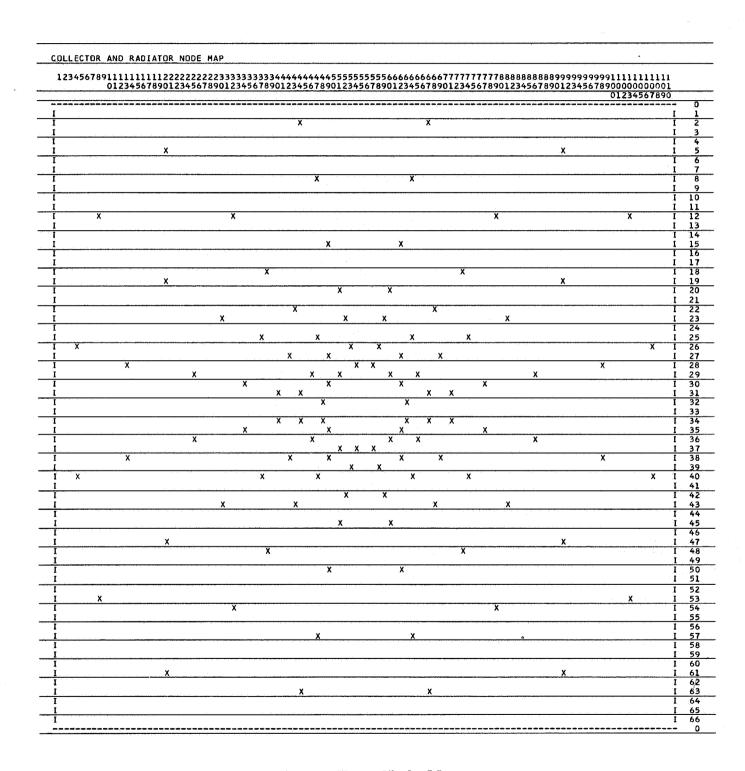


Figure IV-5. Four Node Map

Table IV-1. Three Node Specification

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Table IV-2. Four Node Specification

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49 38	0.2384E-00	0.2229E-00	8
6238_	_0.3010E-00_	0.2229E-00	29
69 38	0.3348E-00	0.2262E-00	37
98 38	_0.4773E-00_	0.2284E-00_	47
53 39	0.2587E-00	0.2145E-00	15
58 39	_0.2807E-00_	0.2145E-00	22
4 40	0.1535E-01	0.2122E-00	111
3740_	_0.1790E-00_	0.2091E-00	115
47 40	0.2262E-00	0.2046E-00	9
6440	0.3132E-00	0.2046E-00	30
74 40	0.3604E-00	0.2091E-00	38 48
107 40	0.5240E 00	0.2122E-00	16
52 42	0.2544E-00	.0.1929E-00.	•
59 42	0.2850E-00	0.1929E-00	23 116
30 43	0.1433E-00_	0.1853E-00 0.1790E-00	10
43 43	0.2091E-00	0.1790E-00	31
6843	0.3303E-00		39
81 43	0.3961E-00	0.1853E-00	17
51 45	0.2484E-00	0.1627E-00.	24
60 45 20 47	0.2910E-00	0.1627E-00 0.1521E-00	117
			40
91 47 3848	0.4457E-00	0.1521E-00 0.1433E-00	11
73 48	0.1853E-00 0.3541E-00	0.1433E-00	32
49 50		0.1206E-00	18
62 50	0.2993E-00	0.1206E-00	25
853	0.3434E-01	0.9641E-01	118
103 53	0.5051E 00	0.9641E-01	41
32 54	0.1521E-00	0.9372E-01	12
79 54	0.3873E-00	0.9372E-01	33
47 57	0.2284E-00	0.6211E-01	19
64 57	0.3110E-00	0.6211E-01	26
	0.9641E-01		
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An examination of the data presented by Fuschillo shows that thermal conductivity data are not presented for the thermoelements analyzed. Further, use of the thermoelectric properties presented in his Figures 8 and 9 is not always in agreement with the mean property values utilized for the calculations. Consequently, to provide the same basis between the calculations, the data have been obtained by "back calculations" from his results.

A design point is selected by Fuschillo on page 112 for the manufactured solar flat plate panels. They are stated to have the following characteristics:

Hot Junction Temperature (T _h)	520 ⁰ K
Absorber Relative Absorbtivity (& a)	0.82
Absorber Relative Emissivity (ϵ_a)	0.08
Cold Junction Temperature (T _c)	350 ⁰ K
Radiator Relative Emissivity (6 r)	0.95
Average Figure of Merit ($\overline{\mathbf{Z}}$)	$1.3 \times 10^{-3} {\rm oK}^{-1}$
ZT_{h}	0.67
Power Output	3.3 watts/ft^2
Plate Area (A) to Length (1) Ratio	30 cm
Open Circuit Voltage (V = S A T, S = Seebeck Coefficient)	64×10^{-3} Volts
Internal Plate Relative Emissivity	0.03

Examination of these data shows that Fuschillo's Figure 7, line D is applicable. This yields a value of $\bar{k}A/\boldsymbol{\ell}$ = 0.31 where \bar{k} is the mean thermoelement thermal conductivity. This immediately allows the thermal conductivity of the thermoelement to be calculated. Since \bar{Z} and \bar{k} are now known, and by definition:

$$\overline{Z} = \frac{\overline{S}^2}{\overline{\rho} \overline{k}}$$

where \overline{S} = Seebeck voltage; $\overline{\rho}$ = electrical resistivity

We find:

$$\frac{\overline{S}^2}{\overline{e}} = \overline{k} \quad \overline{Z} = 1.440 \times 10^{-5} \quad \frac{\text{watts}}{\text{cm}^2 - {}^{0}\text{K}^2}$$

From Fuschillo, page 112, for these temperature conditions:

$$V_{o} = S \triangle T = 64 \times 10^{-3} \text{ v.}$$

where V_o = open circuit voltage; Δ T = T_h - T_c

$$S = \frac{64 \times 10^{-3}}{520-350} = 3.82 \times 10^{-4} \text{ v/}^{\circ}\text{K}$$

Now:

$$\overline{S} = \frac{S}{2} = \frac{3.82 \times 10^{-4}}{2} = 1.91 \times 10^{-4} \text{ v/}^{\circ} \text{K}$$

$$\bar{\rho} = \frac{(1.91)^2(10^{-8})}{(1.44)(10^{-5})} = 2.53 \times 10^{-3}$$
 cm

The length of the thermoelements is 0.25 cm. An area to length ratio of thirty (30) yields a corresponding plate side dimension of 2.74 cm. Since the repeating section analyzed by the code is one fourth of the area, or one half of the side dimension, the repeating section analyzed is 1.37 cm which is very close to the value presented in Fuschillo's Figure 11 for the thermoelements which have been constructed and which are analyzed herein.

Fuschillo's analysis, as shown in his Figure 1, is based upon a load resistance equal to the internal thermoelement resistance. Since the tested thermoelement is 0.25 cm long and has a cross sectional area of $(0.1245)^2$ cm², the resistance is:

$$R = \frac{(0.25)(2.53)(10^{-3})}{(0.1245)^2} = 4.07 \times 10^{-2}$$

These data have been utilized in a computer run with the code modified to hold the hot and cold junction temperatures at 520°K and 350°K, respectively. The thermoelectric behavior predicted by Fuschillo was identical to that predicted by the code under these conditions.

The full calculational capabilities of the code were used with the same input data. These results were presented as the sample problem in Section IV-A. A comparison of the calculated temperatures and the results from Fuschillo's Figure 2 is shown in Table IV-3. It is interesting that the computer results for the average collector temperature and Fuschillo's calculations are virtually identical. The computer predicts an average radiator temperature that is 30K lower, a hot junction temperature that is 80K lower, and a cold junction temperature that is 30K higher. The effect is essentially due to temperature gradient in the radiator and collector, which is to be expected. Since the average collector temperature is by definition that temperature which represents the overall collector from a radiant heat rejection standpoint, the agreement between the manual and computer calculations is to be expected. The temperature decrease to 5120K at the hot junction and the increase to 3530K at the cold junction results in a lower

temperature differential across the thermoelement. This in turn causes a six to seven percent decrease in the power output. The three degree difference in the average radiator temperature is probably due to the cross sectional area employed. A difference between the actual number used by Fuschillo and that utilized herein of one percent in the linear side dimension would account for this difference. It would also account for the slightly higher average collector temperature.

Table IV-3 Comparison of Computed Temperature Data

<u>Item</u>	Fuschillo	Code
Hot Junction Temperature, ^O K	520	512.39
Cold Junction Temperature, ^O K	350	353.12
Average Radiator Temperature, ^O K	350	346.83
Average Collector Temperature, ^O K	520	520.61

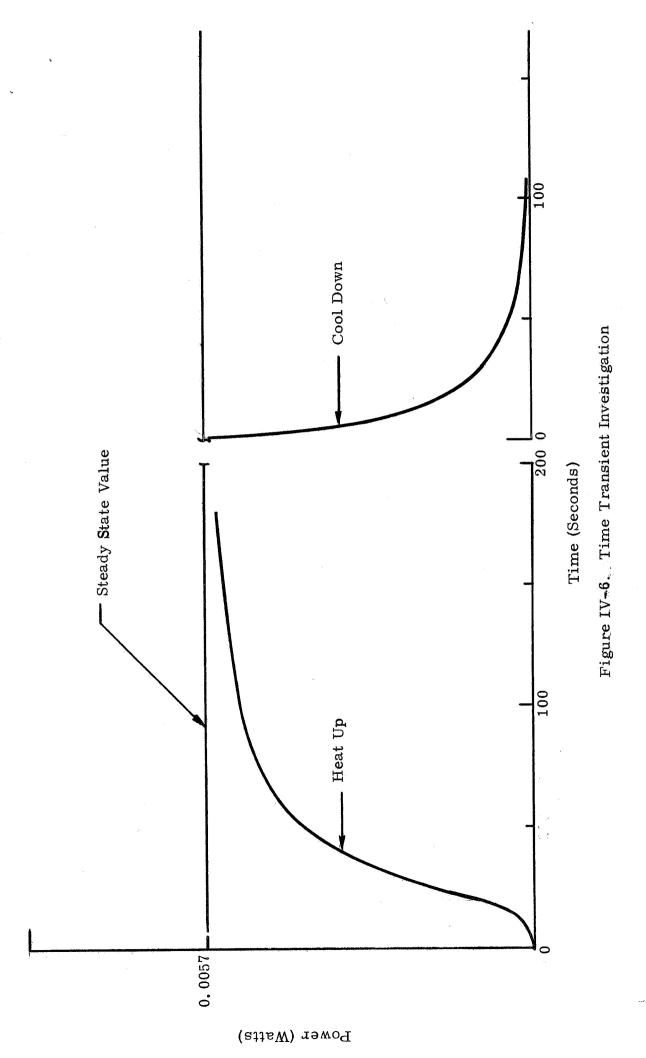
C. Transient Behavior

A transient investigation was conducted to estimate the time required for the solar flat plate to reach its steady state value and also to investigate how rapidly the power dropped when the solar input was removed. The heat up curve shown in Figure IV-6 indicates that the power output is to within 90 percent of the steady state value in 100 seconds and is approaching the steady state value at 200 seconds. The cool down curve indicates that the power output drops extremely rapidly when the solar flux is removed and is approximately one half of the steady state value within 15 seconds.

D. Parametric Investigation With Constant Properties

Variation of the design parameters is of particular interest to this program because of its extensive calculational capability. The data presented in this section are based upon the bismuth telluride data which have been utilized for the previously presented calculations.

The effective changes in the collector and radiator thickness are indicated in Figure IV-7. The present configuration is considered to have a collector thickness of 0.002 in. and a radiator thickness including the effect of the stiffening rib of 0.0025 in. This operating point is indicated in the Figure. The power output shown is for one repeating section of the plate. The efficiency is based upon the electrical power produced at a useful load compared to the energy intercepted by the plate. As would be expected, the effect of increasing collector thickness or radiator thickness



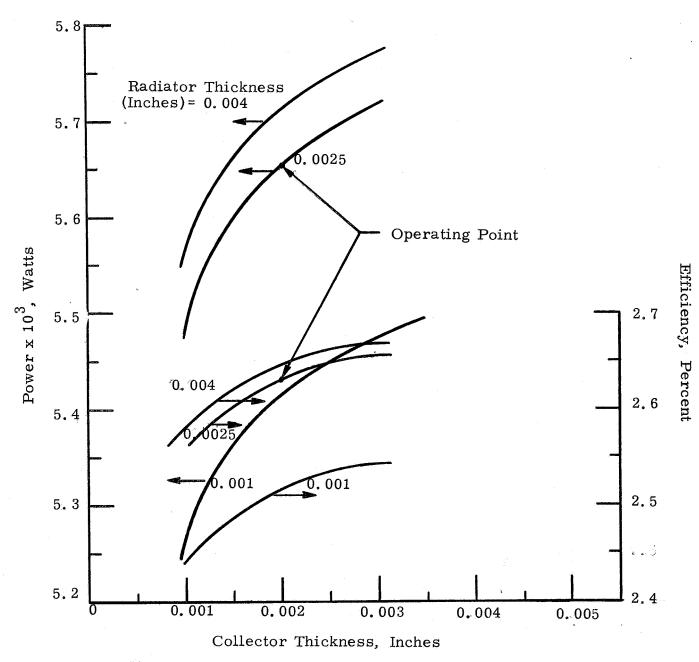


Figure IV-7. Effect of Changes in Plate Thickness

is to increase the power output as well as the efficiency. The effect is relatively flat with respect to thickness for small changes (the scales in Figure IV-7 may be somewhat misleading). However, a change in thickness of both collector and radiator from 0.001 in. to 0.004 in. results in a ten percent increase in the power output, which indicates that larger changes are not negligible.

The effect of changing the thermoelement length with all other parameters constant is indicated in Figure IV-8. This figure immediately shows that the overall efficiency of the configuration will increase as the thermoelement length is increased. This particular effect could not be observed utilizing the approach taken by Fuschillo because of his assumption that the internal load resistances were equal. It is known that the best efficiency for conversion of heat to electricity with thermoelements occurs when the load resistance is approximately twenty to forty percent greater than the internal resistance of the thermoelements. This occurs because of the secondary effect of Peltier cooling which is increased by increasing current. Figure IV-8 indicates that the present thermoelements are not an optimum configuration with respect to the thermoelement area to length ratio since the efficiency and power are increasing as the thermoelement length increased. Further, the load resistance utilized for this combination is also not an optimum. This would indicate that further analysis should be employed to generate a more optimum configuration.

The effect of changing the load resistance is shown in Figure IV-9. The present operating point occurs with a load resistance of 0.0407 ohms. This figure indicates that the power output and efficiency will increase with increasing load resistance with a maximum in the vicinity of 0.05 ohms. This value is in the range of the optimum ratio of external to internal load which would normally be expected. The effect of contact resistance or other internal resistances is also indicated in Figure IV-9. This indicates the need for minimizing such resistances, and also strongly emphasizes the need for including them in calculations if realistic answers are to be obtained. It perhaps should be emphasized that all previous answers presented in this analysis have assumed a zero contact resistance and have additionally assumed no wiring resistance.

E. Parametric Investigations Conducted With Variable Bismuth-Telluride Properties

Bismuth-telluride properties should not be represented as constants for parametric studies, particularly when the temperature can change drastically, because—several of the variables are immediately being ignored. Typical bismuth-telluride data are shown in Figures IV-10 through IV-12. The thermal conductivity information principally is based upon estimates. These data have been utilized in several additional parametric studies.

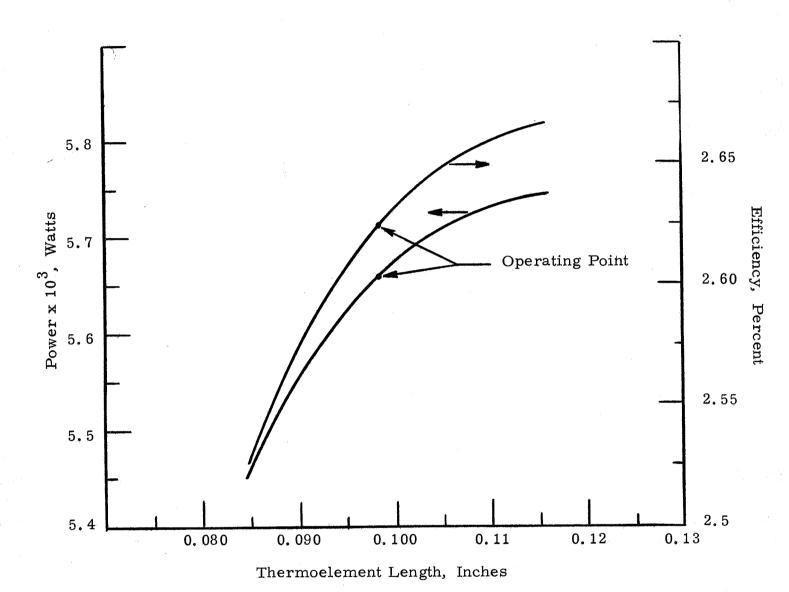


Figure IV-8. The Effect of Changing Thermoelement Length With a Load Resistance of 0.0407 Ohms

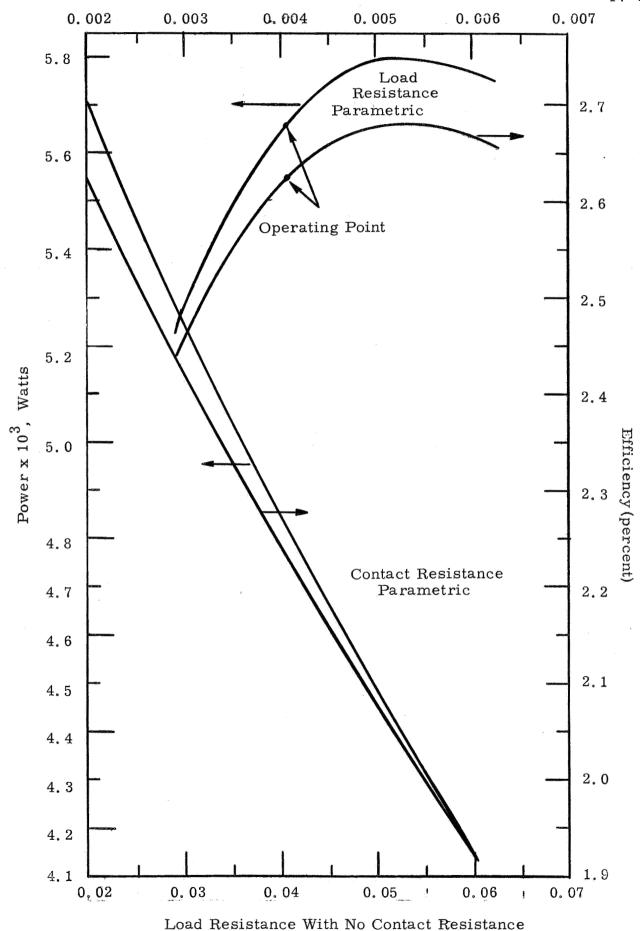


Figure IV-9. Effect of Load and Contact Resistance

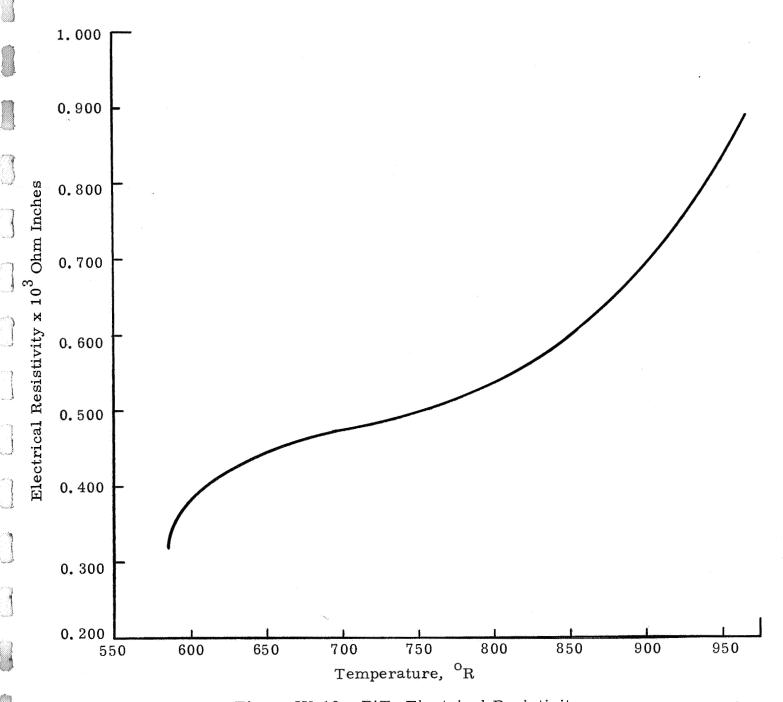


Figure IV-10. BiTe Electrical Resistivity

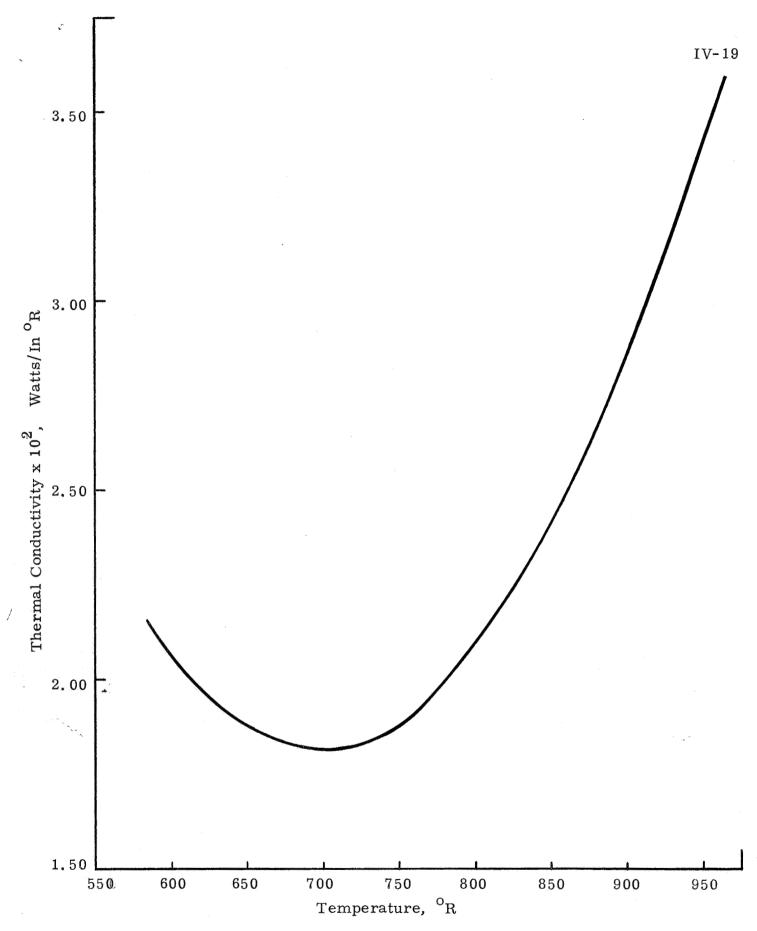


Figure IV-11. BiTe Thermal Conductivity

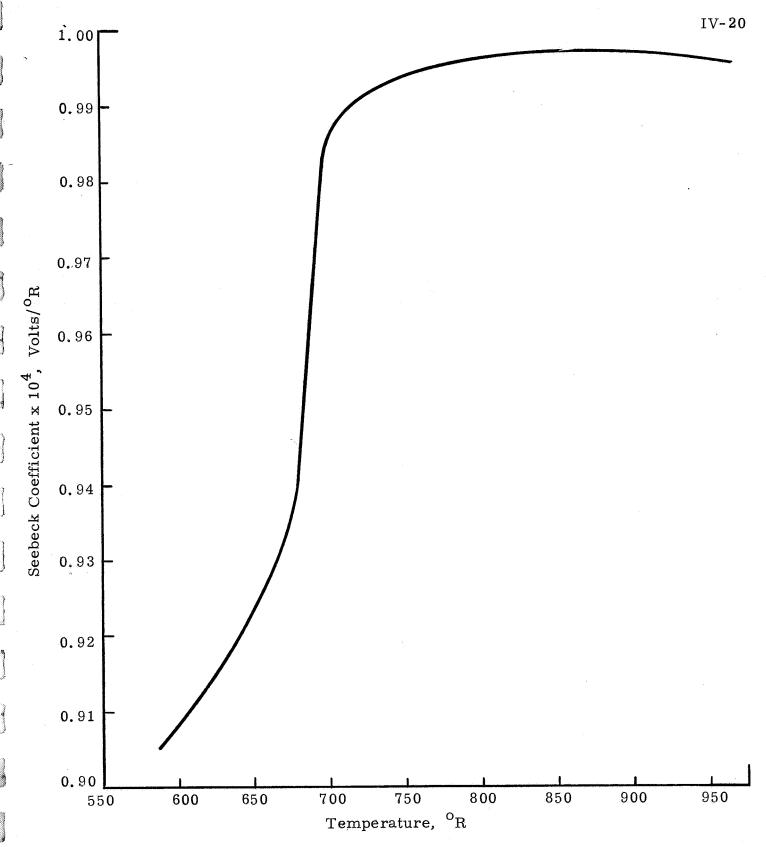


Figure IV-12. BiTe Seebeck Coefficient

The effect of variations in the collector and radiator thickness is shown in Figure IV-13. The reason for the lower power output of these runs as compared to the previously presented information is due to the data used, a mismatch in the load resistance, and the configuration being further removed from optimum than was previously the case. This effect is further indicated in Figure IV-14 which indicates the effect of changing thermoelement length. The steepness of the power output curve with respect to thermoelement length indicates the distance that the indicated design point is removed from the optimum point.

The effect of changing load resistance and contact resistance with these data is indicated in Figure IV-15. The conclusions previously mentioned in regard to contact and wiring resistance remain unchanged. However, here it is seen that the power output, and hence the efficiency, is decreasing with increasing load resistance. This is taking place because the resistivity of the bismuth-telluride used for these calculations was lower than the previous values, and the optimum load resistance is on the opposite side of the operating point.

The effect of changing the plate area while holding other independent values constant is shown in Figure IV-16. As would be expected, the power input increases with increasing surface area because this allows the collector to run hotter while the radiator runs cooler. Of particular interest, however, is the effect of changing the area on power density. Here, it is seen that a maximum is obtained as the area is properly matched to the thermoelement characteristics. This immediately indicates the importance of considering the variation of plate area on the power density. It is further expected that the effect of plate thickness has a rather large effect on the optimum area because of the temperature gradient which would occur.

These parametric studies show that to realize the best performance it is necessary to optimize with respect to thermoelement length, thermoelement cross sectional area, load resistance, and plate area. Further, the effect of plate thickness will have a perturbing effect on the conclusions. In general, the thicker the plate, the more attractive will be the performance, but the heavier will be the resulting solar panel.

F. Solar Flat Plate Using Silicon-Germanium Thermoelements

Application of the solar flat plate to produce electrical power for missions close to the sun is particularly attractive if high temperature thermoelements are utilized. Bifano* has reported results for several investigations at varying distances from the sun. Two of his investigations have been selected for comparison purposes, at 0.388 and 0.25AU from the sun. Typical characteristics are presented in Table IV-4. Since he did not present silicon germanium data, data for this material was obtained from

^{*}Bifano, William J., "Analysis of Solar Thermoelectric Flat-Plate Generators Operating in the Range of 1.0 to 0.1 Astronomical Unit", E-3478, Lewis Research Center, NASA, Cleveland, Ohio.

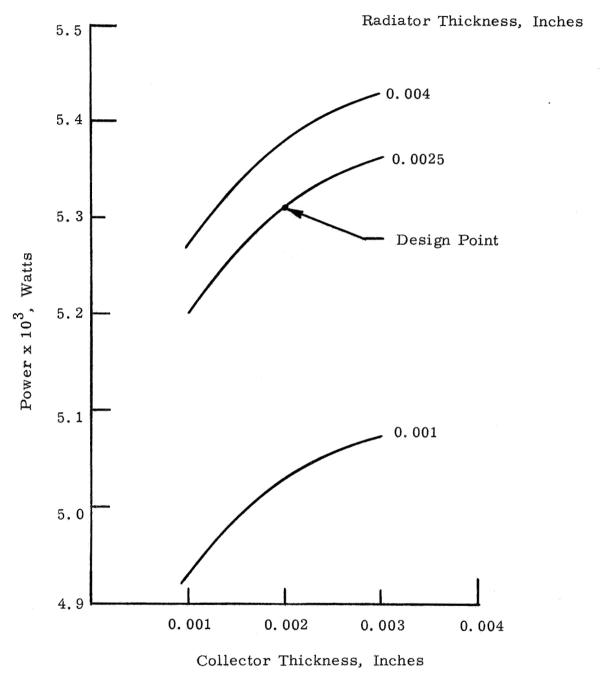


Figure IV-13. Thickness Parametric With Variable Bi-Te Properties

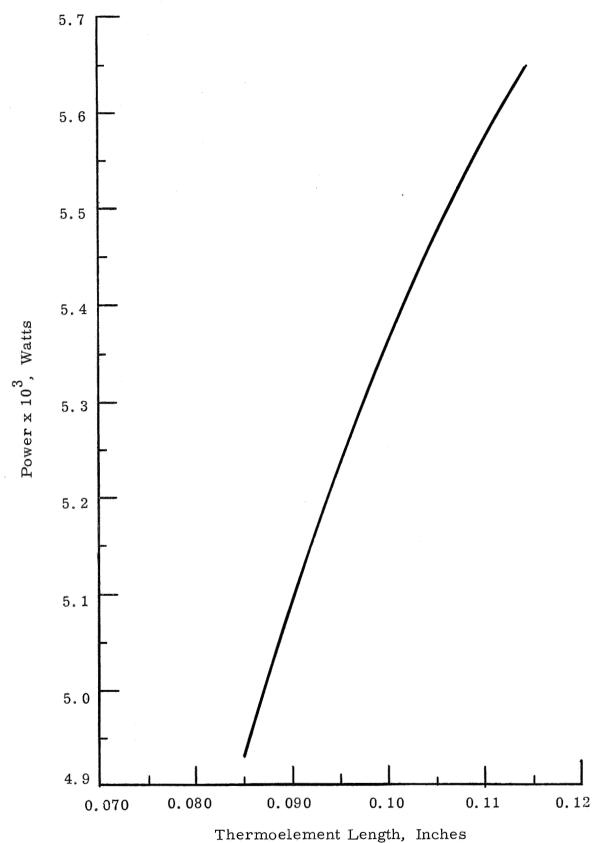


Figure IV-14. Thermoelement Length Parametric With Bi-Te Variable Properties

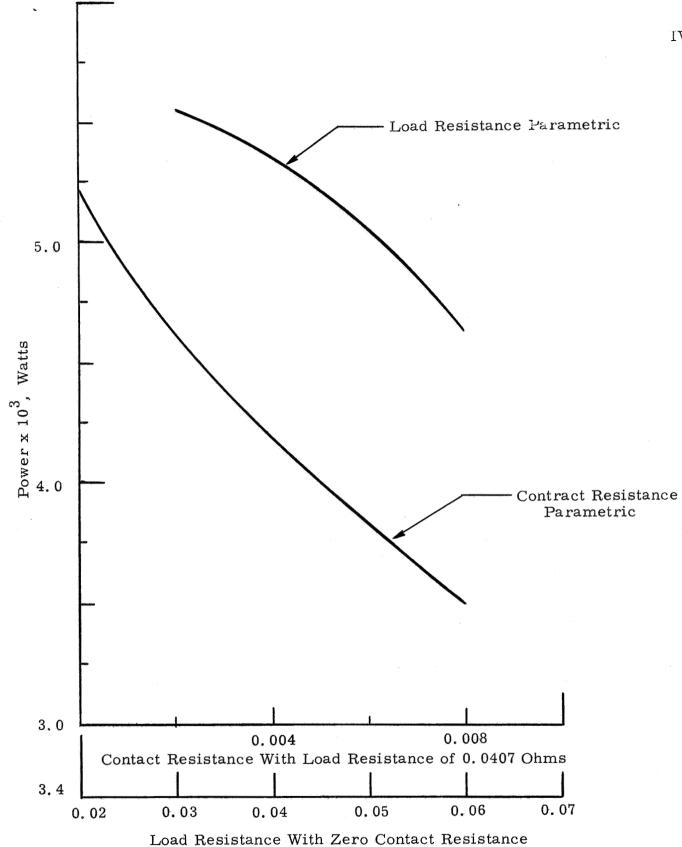


Figure IV-15. Bi-Te Variable Properties Resistance Parametric

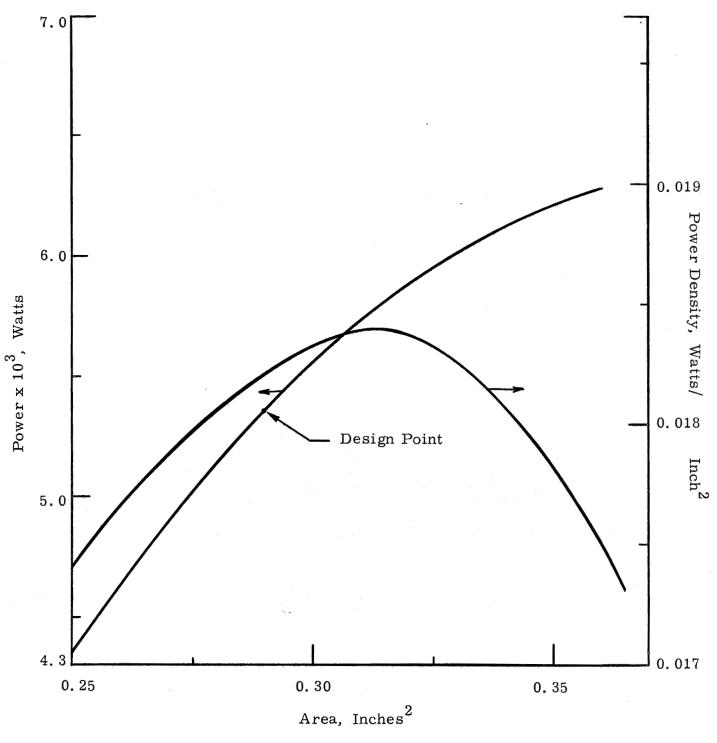


Figure IV-16. Plate Area Parametric Bi-Te Variable Properties

RCA for purposes of the calculation. These data are presented in Figures IV-17 through IV-19 (inclusive). The collector and radiator surface characteristics with the exception of the internal surface are shown in Figure IV-20.

TABLE IV-4. SOLAR FLAT PLATE CHARACTERISTICS FOR HIGH TEMPERATURE APPLICATIONS

Case I:	Distance	from	Sun	=	0.	388ATI
Case I.	DIBLOTIC	TT ()111	Duil		\mathbf{v}	000230

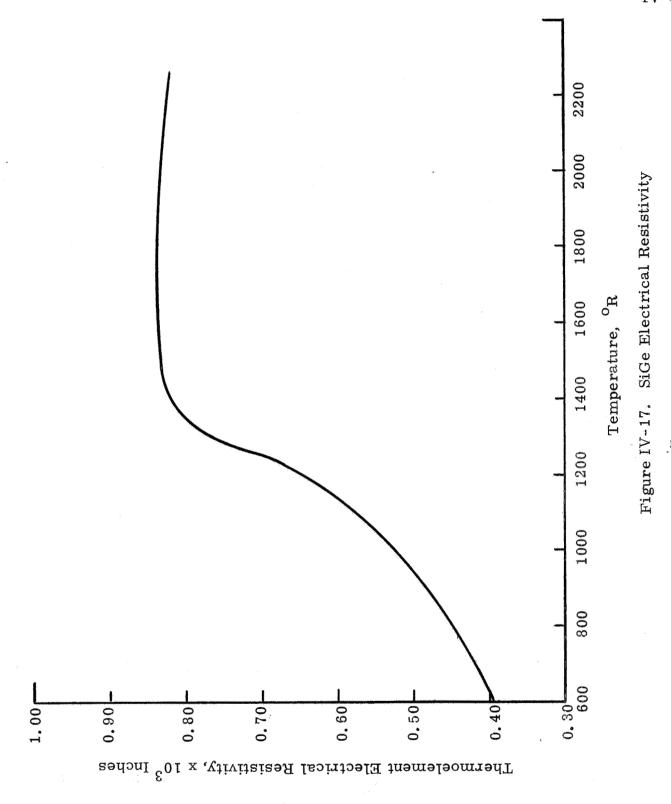
Collector Material	Molybdenum
Radiator Material	Molybdenum
Thermoelement Material	Silicon-Germanium
Collector Thickness	0.005 in
Radiator Thickness	0.005 in
Thermoelement Length	0.24 in
Collector or Radiator Side Dimension	0.804 in
Thermoelement Side Dimension (equivalent	0.088 in
Interplate Relative Emissivity (assumed)	0.03
Solar Flux	6w/in^2
*Case II: Solar Distance = 0.25AU	
Plate Side Dimension	0.574 in
Thermoelement Side Dimension (equivalent	0.088 in
Solar Flux	14.4w/in ²

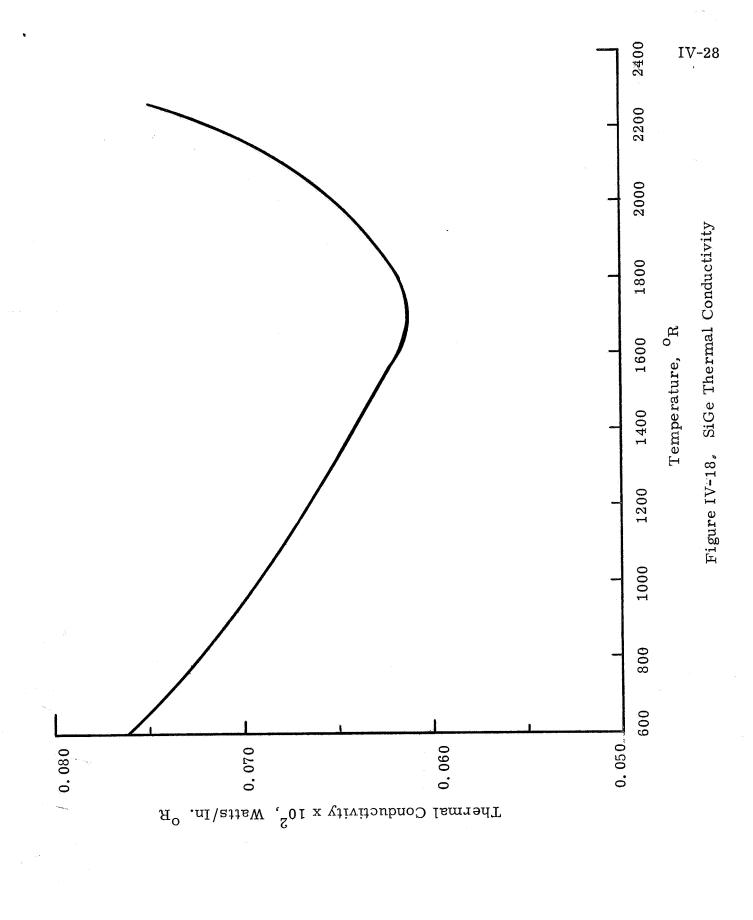
^{*}NOTE: All other items identical to Case I values

A comparison of the characteristics computed by Bifano and those obtained by the computer program is shown in Table IV-5 for the Case I calculations.

TABLE IV-5. CALCULATED RESULTS FOR SOLAR FLAT PLATE AT 0.388AU FROM THE SUN

<u>Item</u>	Bifano	Computer Program
Hot Junction Temperature (^O R)	1660	1544.5
Cold Junction Temperature (^O R)	1000	969.40
Collector Temperature (^O R)	1660	1581.9





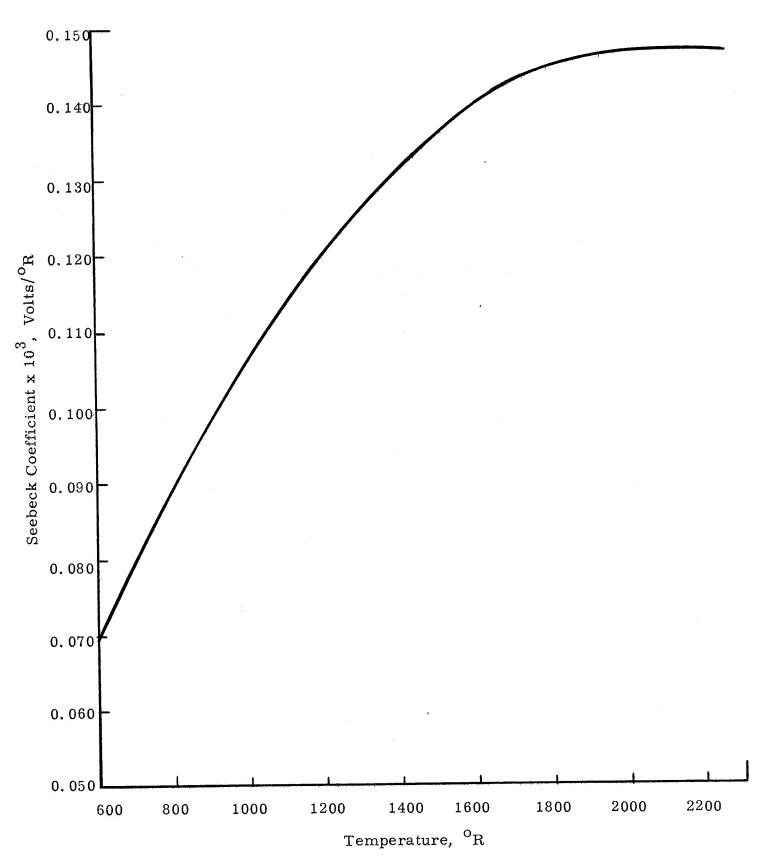


Figure IV-19. SiGe Seebeck Coefficient

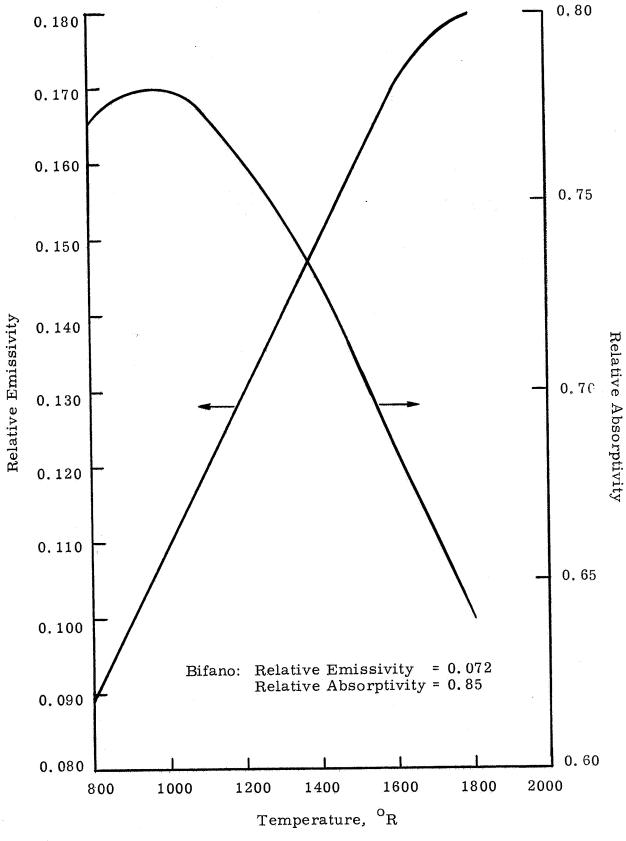


Figure IV-20. Absorber Surface Characteristics

TABLE IV-5. SOLAR FLAT PLATE CHARACTERISTICS FOR HIGH TEMPERATURE APPLICATIONS (CONTINUED)

<u>Item</u>	Bifano	Computer Program
Radiator Temperature (^O R)	1000	935.9
Power Density Based Upon Plate Area (watts/ft ²)	17	11.9

The difference between the calculated power output is due to the decreased temperature difference across the thermoelement which was predicted by the computer program. The reason for the sizeable drop in the collector temperature predicted by the computer program as compared to Bifano's calculations is due to the relative absorptivity of 0.85 which he used compared to the lower values used in the code. A secondary drop in the power output occurs because of the temperature difference in the collector and radiator from the center to the edges. Both of these effects act to decrease the temperature difference across the thermoelement which in turn decreases the output power.

No attempt was made during this investigation to optimize the thermoelement shape with respect to the area to length ratio or the thermoelement dimensions with respect to the plate area. However, the load resistance was varied to assure that the maximum power was being generated. The data presented in Table IV-5 were based upon the best load resistance.

The Case II calculations are summarized in Table IV-6. Again, most of the reason for the difference between the computer predicted power output and that shown by Bifano is due to the lower temperature difference across the thermoelement. This principally results from the lower collector temperature predicted by the computer, but secondarily results from the temperature gradient across the plate which Bifano's calculation could not investigate. Again, the computer results are based upon an optimized power output with respect to variation of the load resistance.

TABLE IV-6. CALCULATED RESULTS FOR SOLAR FLAT PLATE AT 0.25AU FROM THE SUN

Item_	Bifano	Computer Program
Hot Junction Temperature (OR)	2060	1909.5
Cold Junction Temperature (^O R)	1245	1208.3
Average Collector Temperature (OR)	2060	1947.7
Average Radiator Temperature (^O R)	1245	1174.1
Power Density Based on Plate Area (watts/sq.ft.)	49.5	38.1

V. CONCLUSIONS

An accurate mathematical model of the solar flat plate has been obtained and a computer program written for the IBM-7094 has been utilized to obtain solutions for the mathematical model. The predicted characteristics agree closely with the experimental data which are available. Good correlation between the computer calculations and the previously available manual calculations have been obtained when suitable restrictions were placed upon the model utilized by the computer so that it corresponded to that upon which the manual calculations were based. Full use of the computer code capabilities shows a slight decrease in performance from that predicted for the existing configurations with manual calculations.

A number of calculations are possible with this computer program that previously could not be made. Transient behavior of the solar flat plate which results from movement from shade to sun or vice versa conditions may be predicted. The effect of variations in the absorber and radiator thickness can be determined so that true optimization with respect to weight can be considered.

Computer program input is very simplified and a comprehensive logical analysis of the input data is built into the code. Input data are read independent of format or the manner in which the data are written. Comprehensive parametric studies may be easily obtained because only those data which are changed from a previous run need be read by the computer program. Sufficient storage capability for tabular information has been incorporated into the computer program so that physical property data for several materials of interest may be stored and referred to by the computer as desired.

Although the program in its present form is quite generalized and applicable to most situations, its application to segmented or multiple thermoelements or the automatic calculation of orbital characteristics is not at present possible. These applications have been anticipated in developing the program and sufficient flexibility has been incorporated into the coding techniques so that the modifications may be made in a straightforward manner, if desired, at a later date.

APPENDIX A

DISCUSSION OF THE SELECTION OF A COORDINATE SYSTEM

APPENDIX A

Discussion of the Selection of a Coordinate System

Two basic approaches may be utilized in the solution of a heat conduction problem using numerical techniques. In the first, a differential equation represents the starting point, and the differential equation is expressed as a difference equation. This is solved by using suitable calculation techniques. In the second, the geometry which is to be analyzed is broken up into a number of small volumes, and each volume is considered to be represented by the properties of a point assigned within the volume. Normally, the points are called nodes and are considered as being interconnected to other nodes by conductances. The transient behavior of the volumes is represented by the "capacitance" of the volume, which may be obtained immediately from the heat capacity, the volume and the density. Representation in this technique essentially analyzes the equivalent electrical circuit to the heat conduction problem. Either approach should yield identical results if the analysis is applied properly.

The differential equation applicable to the solar flat plate absorber or radiator is second order with respect to x and y in the Cartesian coordinate system. This means that if it is reduced to a difference equation, the temperatures in the steady state representation for a central node and four surrounding nodes will appear if a Taylor series expansion of the second derivative is used and higher order terms are neglected. It is common practice to solve equations of this type using equal spacing between all node centers. Since the absorber or radiator surface area is large compared to the cross sectional area of a thermoelement, a node size that was uniform everywhere would be determined by the minimum node size acceptable along a line of intersection between the thermoelement and the absorber or radiator, because the heat flux is highest at this line. Such an approach would result in a very large number of nodes being required for the analysis of the heat conduction. Although there is nothing wrong with this insofar as accuracy is concerned, the computation time increases very rapidly as the number of nodes is increased because the number of iterations required to attain suitable convergence becomes very large.

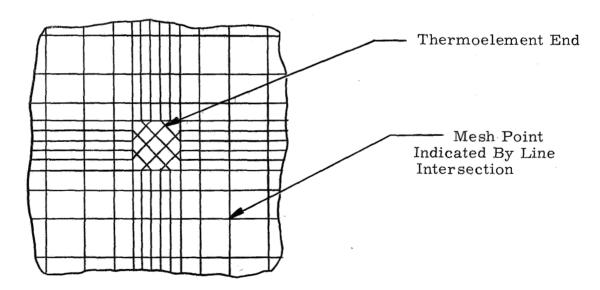
All of the heat absorbed at the hot end of the thermoelement must be conducted to that position from the absorber plate. Since the thermoelement end is small, the assumption was made that the thermoelement temperature at the hot junction could be represented by a single value. It is therefore reasonable to assume that the entire portion of the absorber formed by an extension of the thermoelement peripheral surfaces perpendicular to the plane of the absorber is also a uniform temperature region. This means that all of the heat collected by the absorber, with the small exception of that which is radiated directly to the small uniform region, must be conducted through this "thermoelement peripheral area". The heat fluxes in this region will be quite high, as will the temperature gradients. If an imaginary path is selected which is perpendicular to the periphery of the thermoelement and lies within the absorber, and one investigates temperature gradient while traveling along this path away from the thermoelement, it will be found that the gradient lessens and approaches zero at the edge of the absorber. Since

the gradients are smaller further away from the thermoelement, larger sections of the absorber could be selected to be represented by a single node and an acceptable accuracy would still be attained. This immediately suggests that a numerical technique is desired wherein the size of the section assigned to a node is increased with increasing distance from the thermoelement. This will considerably reduce the required computation time with little or no loss in accuracy. An approach of this type is perhaps most easily understood by considering the electrical analog to heat transfer which was previously mentioned.

In utilizing this approach, it is vitally important to represent each node in a suitably designed configuration. It must be remembered that even though it may appear that a somewhat arbitrary approach is being taken, it is still necessary to mathematically represent the behavior. A haphazard sort of arrangement of interconnecting the nodes will not reduce to the necessary differential equation when the node size is allowed to approach zero. If the differential equation is not realized, then the required numerical solution may also not be realized.

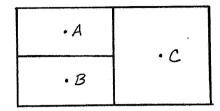
We therefore restrict the discussion for the present time to the selection of rectangular nodes which fit within the rectangular geometry which describes the absorber and connected thermoelement.

If we first consider that a large number of nodes must intersect the thermoelement-absorber intersection, and we wish to reduce the number of nodes as the distance from the thermoelement is increased, an arrangement of the following type can occur:



Although this reduces the number of points required for calculation purposes, we notice there are still a large number of extra points not required for accuracy. The ability to eliminate these is also important.

We now consider the following mesh point arrangement and surrounding area:



If the points A, B and C are properly interconnected so that this mesh is the equivalent of:

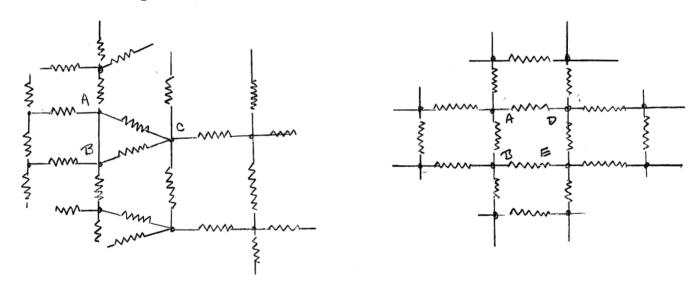
• A	· D
·B	• E

then we can construct:

Here we see that the number of points is high near the thermoelement where the heat fluxes are high, and becomes lower as one moves away from the high heat flux area. The accuracy is maintained, and the number of mesh points reduced further.

To introduce "no" error in the system means that the conductances (or resistances) of each of the grids must give identical behavior of the mesh. Further, the capacitances associated with each of the points must also give the "same" overall mesh behavior. In our case, the grid is further complicated by the addition and loss of heat over the surface, which must also be included. Immediately, it is seen that the connecting of the mesh points is not just an arbitrary selection, but must be done carefully with a complete understanding of the heat conduction problem.

For this system to work properly, the electrical circuits shown in the following sketch must be identical:

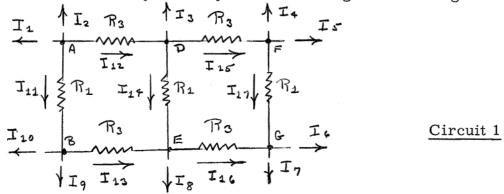


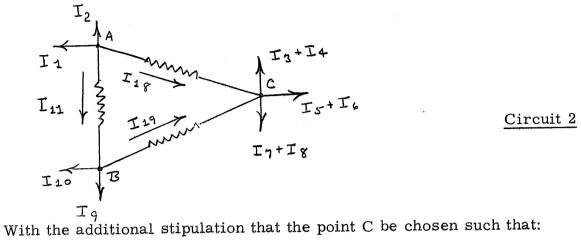
Reduction of Points Mesh

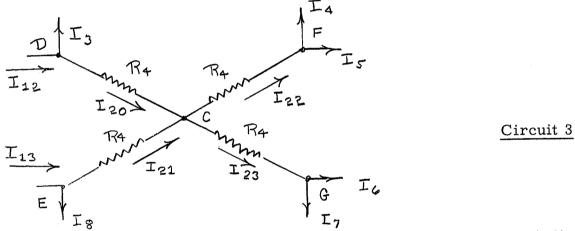
"Exact" Mesh

This requires careful calculation of all of the individual connectors, capacitances, etc., a problem generally ignored.

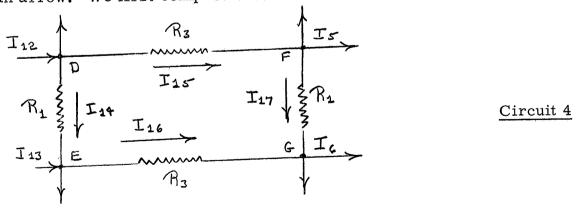
These circuits may be analyzed considering the following configurations:







Where I = current, R = resistance, the first direction of which is indicated by an arrow. We first compare circuit 3 to:



Immediately we see that:

$$V_D - I_{15} R_3 = V_F$$
 (A-1)

$$V_D - I_{20} R_4 - I_{22} R_4 = V_F$$
 (A-2)

Subtracting:

$$-I_{15} R_3 + \left[I_{20} + I_{22}\right] R_4 = 0 \tag{A-3}$$

Similarly:

$$I_{14} R_1 + \left[I_{21} - I_{20} \right] R_4 = 0$$
 (A-4)

$$I_{16} R_3 - I_{23} + I_{21} R_4 = 0$$
 (A-5)

$$-I_{17} R_1 + \left[-I_{22} + I_{23}\right] R_4 = 0$$
 (A-6)

Further:

$$I_{20} = I_{14} + I_{15}$$
 (A-7)

$$I_{22} = I_{15} - I_{17}$$
 (A-8)

$$I_{21} = -I_{14} + I_{16}$$
 (A-9)

$$I_{23} = I_{16} + I_{17} \tag{A-10}$$

Using this, Equations (A-3) through (A-6) become:

$$-I_{15} R_3 + \left[I_{14} + I_{15} + I_{15} - I_{17}\right] R_4 = 0$$
 (A-11)

$$I_{14} R_1 + \left[-I_{14} + I_{16} - I_{14} - I_{15} \right] R_4 = 0$$
 (A-12)

$$I_{16} R_3 - I_{16} + I_{17} - I_{14} + I_{16} R_4 = 0$$
 (A-13)

$$-I_{17} R_1 + \left[-I_{15} + I_{17} + I_{16} + I_{17}\right] R_4 = 0$$
 (A-14)

which can be rewritten:

$$I_{15} \left[2R_4 - R_3 \right] + I_{14} R_4 - I_{17} R_4 = 0$$
 (A-15)

$$I_{14} \left[-2R_4 + R_1 \right] -I_{15} R_4 + I_{16} R_4 = 0$$
 (A-16)

$$I_{16} \left[-2R_4 + R_3 \right] + I_{14} R_4 - I_{17} R_4 = 0$$
 (A-17)

$$I_{17} \left[2R_4 - R_1 \right] - I_{15} R_4 + I_{16} R_4 = 0$$
 (A-18)

Now subtract Equation (A-17) from (A-15):

$$\left[I_{15} + I_{16}\right] \left[2R_4 - R_3\right] = 0 \tag{A-19}$$

Immediately:

$$R_4 = \frac{R_3}{2}$$
 (A-20)

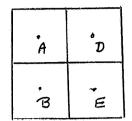
Finally, subtract Equation (A-18) from (A-16):

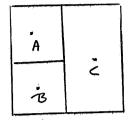
$$\left[I_{14} + I_{17}\right] \left[-2R_4 + R_1\right] = 0 \tag{A-21}$$

$$R_4 = \frac{R_1}{2}$$
 (A-22)

But Equations (A-20) and (A-22) contradict unless $R_1 = R_3$, which immediately indicates that circuits 3 and 4 cannot be made equivalent except for square arrays, a prohibitive requirement since a non-square rectangular mesh is necessary for the general case. It is concluded that a mesh of the type indicated in configuration 2 cannot be converted to configuration 1 with the connecting point (C) in the center of the block (the circuit 3 requirement).

We therefore reject the requirement that we expand in both directions at once, and instead consider the change from configuration 2 to 3:

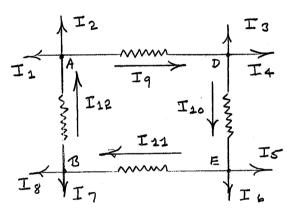




Configuration 2

Configuration 3

which have the equivalent circuits:

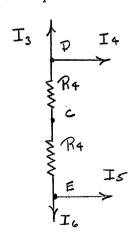


 R_{12} R_{1} R_{2} R_{2} R_{2} R_{2}

Circuit 5

Circuit 6

Here we require that:

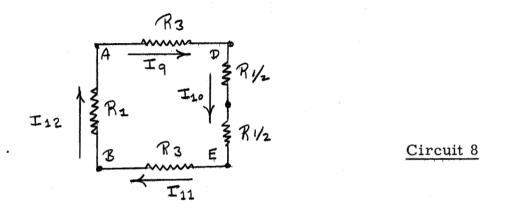


Circuit 7

since C is at the midpoint of D and E, and further that:

$$R_4 = \frac{R_1}{2}$$
 (A-23)

which fixes the position of C as in the midpoint of rectangle C. We immediately see that circuits 5 and 7 can be combined to:



and this gives behavior identical to circuit 5. We now require that circuits 6 and 8 give identical behavior insofar as points A and B are concerned. Hence:

$$V_A - I_{13} R_2 = V_C$$
 (A-24)

$$V_{C} - I_{14} R_{2} = V_{B}$$
 (A-25)

$$I_{13} = I_9$$
 (A-26)

$$I_{14} = I_{11}$$
 (A-27)

$$V_A - I_9 R_3 = V_D$$
 (A-28)

$$V_D - I_{10} = V_C$$
 (A-29)

$$V_{C} - I_{10} = V_{E}$$
 (A-30)

$$V_{E} - I_{11} R_{3} = V_{B}$$
 (A-31)

Now subtract Equation (A-30) from (A-29):

$$V_D - I_{10} = V_C + I_{10} = V_C - V_E$$
 (A-32)

$$2V_{C} = V_{D} + V_{E} \tag{A-33}$$

$$V_{C} = \frac{V_{D} + V_{E}}{2}$$
 (A-34)

(which would be expected).

Now substitute Equations (A-28) and (A-31) in (A-34):

$$V_{C} = \frac{V_{A} - I_{9} R_{3} + V_{B} + I_{11} R_{3}}{2}$$
 (A-35)

Now we use Equations (A-24) through (A-27) with (A-35) to obtain:

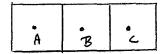
$$2V_C = V_C + I_9 R_2 - I_9 R_3 + V_C - I_{11} R_2 + I_{11} R_3$$
 (A-36)

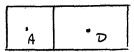
$$I_9 \left[R_2 - R_3 \right] - I_{11} \left[R_2 - R_3 \right] = 0$$
 (A-37)

which for the most general behavior requires simply that:

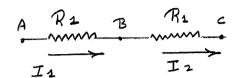
$$R_2 = R_3 \tag{A-39}$$

This enables us to expand the mesh in one direction (say, for example, the y direction). We now must derive a technique that will enable expansion in the other direction (the x direction). Hence we require that the following configurations be equivalent:





The equivalent circuits are:



Circuit 9

Circuit 10

Since we are doubling size, and D is to be placed at the midpoint, there results:

$$R_2 = \frac{3R_1}{2} \tag{A-40}$$

as the requirement that positions point D. Further, we see that:

$$V_A - I_1 R_1 = V_B$$
 (A-41)

$$V_{A} - I_{1} R_{2} = V_{D}$$
 (A-42)

which combine to form:

$$V_A - I_1 \frac{3R_1}{2} = V_D$$
 (A-43)

$$\frac{2V_{A}}{3} - I_{1} R_{1} = \frac{2V_{D}}{3}$$
 (A-44)

$$\frac{V_A}{3} = V_B - \frac{2V_D}{3} \tag{A-45}$$

$$V_{A} = 3V_{B} - 2V_{D}$$
 (A-46)

$$V_{\rm D} = \frac{3V_{\rm B} - V_{\rm A}}{2}$$
 (A-47)

which is reasonable weighting and replacing circuit 9 by 10 is therefore reasonable. Similar changes may be made if other than doubling of the mesh size is desired.

This academic type discussion indicates that the node interconnection problem is more complicated than generally realized. It further indicates that if the rectangular type of coordinate system is to be utilized, it is going to be difficult to obtain suitable expansion factors in going from one node size to another so that suitably sized nodes can be fitted to the different requirements of the plate edge as compared to the intersection of the plate with the thermoelement.

It is not absolutely necessary that the electrical analogy hold identically, as implied in the foregoing analysis. If suitable resistances are selected which come close to representing the overall behavior, suitable answers will still be attained. Such a relaxation of the rigorousness of the approach is commonly utilized, but the authors suspect that the assumptions involved are not fully understood.

One of the basic requirements imposed upon the analysis was that the resulting computer program should be "easy to use". The authors concluded early in the study of mesh arrangements that the only information necessary for general prescription of the solar flat plate was the coordinates of the corners of the plate and of the thermoelement along with specifications in regard to the number of mesh points which should be used. A mesh generation technique which was easier to set up in a logical manner than the rectangular approach just discussed was therefore desired. As a result, the rectangular system was rejected in favor of the cylindrical coordinate system.

The cylindrical coordinate system with the origin centered at the thermoelement fits the requirements for an expanding mesh very nicely. The width of "rays" close to the thermoelement is small, and increases with increasing distance from the thermoelement. Selection of increment sizes such that an approximately "square" node results allows the automatic generation of the desired nodal arrangement.

A complication with the cylindrical geometry approach that was not evident in the rectangular geometry approach is the "non-fit" of the geometry to the thermoelement-plate intersection and to the outside edges of the plate. The logic involved in these sections was easier to set up than was the logic involved in generating an expanding generalized node system based upon rectangular geometry. Cylindrical geometry was therefore selected as the basis for the calculations.

APPENDIX B

PROGRAM LISTING

```
LIST, DECK, DD, XR7
SIBFTC MAIN
C FLAT PLATETY
                                  G'ENERATOR ANALYSI
  C. ANDERSON AND W. LYON, HITTMAN ASSOSIATES, DALTIMORE, MD., 1966
     COMMON Z-
     DIMENSION Z(20000), MAZ(12), JS(6), MS(12), TAB(10), ITABA(30), ICA(200
     2), ICS(200)
      EQUIVALENCE (Z(1), IN), (Z(2), IOUT), (Z(3763), MS(1)), (Z(614), MA2(1)),
     3NOLU), (Z(663), NP4), (Z(2433), ITAB(1)), (Z(15940), ITABA(1)), (Z(15740)
     4 • I CA(1) ) • (Z(2233) • I CS(1)) • (Z(3746) • JZZ) • (Z(11) • LERR) • (Z(3) • I QUIT) •
     5(Z(6316),A(1)),(Z(9016),CENX(1)),(Z(9916),CENY(1)),
     6(Z(8116), PLEIN(1)), (Z(10816), NODE(1)), (Z(7216), PLEBAK(1)),
     7(Z(12816), CONDB(1)), (Z(11916), CONDI(1)), (Z(13716), T(1)),
     9(Z(15066), EPSC2(1)), (Z(15066), EPSR1(1)), (Z(15516), EPSR2(1))
      EQUIVALENCE (Z(9016),ALFH(1)),(Z(9916),T4(1)),(Z(16416),TERMF(1))
     1) • (Z(10816) • TERMO(1)) • (Z(4409) • TMAP) • (Z(5200) • LB • L22) • •
     3(Z(5213),L2),(Z(5214),ITOT,IX),
     <del>4(Z(16416),NOD(</del>1)),(Z(14616),XPRNT(1)),(Z(15516),YPRNT(1));
     5(Z(4408),XINPUT),(Z(4),k),(Z(4410),ISS)
     NAMELIST/NAMI/
C
      SET VARIABLES FOR PROBLEM USING ALL NEW DATA
                                                                          MAI
  1<del>03</del> DO 260 1=1,20000
  260 Z(I)=0.
     SET TAPE DESIGNATIONS: IN IS INPUT: TOUT OUTPUT
                                                                          MAT
      IN=5
                                                                          MAI
     I-OUT=6-
                                                                          MAI
      SET VARIABLES FOR PROBLEM USING PARTIAL NEW DATA
                                                                          MAI
---239-D0-3-I=2,6
    3 JS(I) = 0
                                                                          MAI
    ----READ--INFORMAT-ION-
    9 CALL READIT(JZZ)
     -IF(IQUIT)103,210,210
C
      PROCESS NUMBERS FOR CORRECT LOGIC AND PLACE IN CORRECT LOCATIONS.
     JS IS * INFORMATION, CONTAINS O IF NOTHING WAS READ.
  210 IF(JS(3)+JS(4))100,4,26
  26 CALL PACK
      GO TO 4
  100 WRITE(IOUT, 101)
  101 FORMAT (32HOMACHINE ERROR - 1 GOOFED - MAIN)
   11 CALL EXIT
    4 DO 10II=2,6
     GO TO (100,12,14,13,15,16),II
   12 IF(JS(2))100,10.6
   6 CALL PRO2
   18 IF(LERR)100,10,,,
   17-JZZ=1-
      IF(K-8)9,103,11
   13 IF(JS(5))100,10,29
   29 CALL PRO5
     -GO-TO-18-
   14 IF(JS(6))100,10,30
   30-CALL-PRO6-
     GO TO 18
```

673	and a second	and the second s		and of the Services	and the second s
_	- 15 IF(JS(3))100,10,31		a contrador altera e incluira con estado de contrador e contrador de contrador de como contrador de contrador		e consider y similarity france on the second of the second
	31 I=JS(4)				
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	CALL UNPAK	in the second se	and the second	encina imalik kajanganan en mara en sim	nga sa pangangangangang pangkanan ngga dan panggan panggan panggan panggan panggan panggan panggan panggan pan
.07700	DO 35 J=1,1580				
	35 Z(J+10249)=Z(J+3758)	and the second s	w v _nage, where any analysis and any and a second	,	
	CALL PRO3				
***************************************	RESTORE LOWER MEMORY	ar ay ngangsangan men aksa minakki ng Salayang Salayang Salayang san "Ang dinakang Pal	To		
	DO 36 J=1,1580	· · · · · · · · · · · · · · · · · · ·			
4000	36 Z(J+3758)=Z(J+10249) JS(4)=I				
	GO TO 18	an in the second se			
	16 IF(JS(4))100,10,37				THE REPORT OF THE PROPERTY OF
DESTRUCTION PROPERTY.	15 (3) - C	and the second of the second o			
	JS(3)=0 CALL UNPAK	Andreasina			
	CALL PRO4				
	JS(3)=I	. airceann	in model (Section Section Sect		namen and the state of the stat
	GO TO 18				and the second section of the section of the second section of the section of the second section of the section of th
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	310 CALL MESH				
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1	251 CALL MESHALA, CENX, CENY, PI	_EBAK,PLEIN	NODE, IX, L2)		
	IF(LERR) 100 : 252 : 17			- Lagrangia dentro La Januario de States	ada ada baban un de calaba kenastatun era da da arterda de ta a Arterda da 1 600 vilan 1800 vilan 1800 vilan 180
	252 CALL MESHE (NODE , A , CENX , CE	ENY, PLEBAK,	PLEIN, IX, L2)	Tuki sarto V . 1 - On	
turn gardenan	CALL MEDIC (CONDB, NODE, CON 309 IF (TMAP 201, 202, 201	NUI PLEBAK 9	CENX (CENT) A 9 I) PLE	INJINJEZ	
<u> </u>	201 CALL FPMAP (CENXICE)	NY, NOD, XPRN	T, YPRNT, IX, L2)	Committee Commit	amentene i Camada con Acada no de la proposa de activa de Sale de Camada no de Camada (Camada Camada Camada C Camada Camada Camad
-1 N/O N	202 IF(ISS) 505,305,304	w			
_	304 CALL CALCS (XK) CAP, EPSC1	EPSC27EPSR1	,EPSR2 ,ALPH , T , A , T	4 9	
	1CONDI, CONDB, TERMF, TERMO,	IX,L2,L22)	i i i supremi i supremi i su primi i mangantana da primi i mangant	nggangan an makingganangan an anggan singka	
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_		1X, 27L	U - C - Suit parties Moderated	CONTRACT OF SAME PROPERTY OF SAME OF S	maken digi gelan karak in melabah kecaman manan melabah di di diaman di dinamah di dengan bersak dan melabah d Terlah
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	IF (IGUIT) 100,238,11	entinger a deligation or	1 49 2 may 1, 1600		
	238 IF(K=6)239,103,11	estation	· Constitution	Proposition of the Contract of	
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SIBFIC READIT - LIST, DECK, DU, XR7
      SUBROUTINE READIT(JZZ)
                                                                             READIT
     .COMMONweedZoneenweenweenweenzeenzeen
                                                                             READIT
      DIMENSION Z(16000), ISS(72), IS(72)
                                                                             READIT
     -EQUIVALENCE-(-Z-(-)-, 1N-) , (-Z-(2) , 10UT-) , (-Z-(3) , 1QUIT-) , (-Z-(4) , K-) , (-Z-(5) , NUM) -- READIT-
     2,(Z(6),IGN),(Z(7),DEC),(Z(8),NUMB),(Z(9),ZEXP),(Z(10),DECP),(Z(11)
                                                                             READIT
     3 ; LERR) - (Z(13) - LINE) - (Z(9900) - ISS(1) - - (Z(9800) - IS(1)) - (Z(832) - MACH) - READIT
     4, (Z(3747), KB), (Z(7900), IG), (Z(7901), ITE), (Z(7902), TEMP)
                                                                             READIT
     INTEGER-A, AST, ZZ, BLANK, DOT, PLUS, E
                                                                             READIT
      DATA A, AST, ZZ, BLANK, DOT/1HA, 1H*, 1HZ, 1H , 1H./, PLUS/1H+/, E/1HE/
                                                                             READIT
CHECK-FOR-NORMAL-ENTRY,321-IS-YES-
                                                                             READIT-
                                                                             NUMBER
      LERR=0
     -IF(JZZ)100<del>,321,32</del>
                                                                             READIT-
                                                                             READIT
  321 K=0
                                                                             READIT
  READIT
    1 FORMAT(72A1)
    500 FORMAT (1H0,72A1)
    --- I A = 1 ---
                                                                             READIT
CHECK FOR *
                                                                             READIT
    READIT
CONTROL CARD, DETERMINE TYPE
                                                                             READIT
   3-15(2)=15(2)/1073741824
                                                                             READIT
      IF(IS(2))9,9,10
    9-IS(2)=IS(2)*1073741824----
      WRITE(IOUT, 500)(IS(I), I=1,72)
     WRITE(IOUT,12)
                                                                             READIT
   12 FORMAT(21HOILLEGAL CONTROL CARD)
                                                                              READIT
  322 CALL EXIT
                                                                             READIT
   10 IF(9-IS(2))9,13,14
                                                                              READIT
   13 IQUIT=1 -
                                                                             READIT
      RETURN
                                                                              READIT
     IF(7-15(2))16516517
                                                                             READIT
  100 WRITE(IOUT, 101) MACH
                                                                              READIT
  101 FORMAT (42HOMACHINE ERROR IN READIT, STATEMENT NUMBER 14)
                                                                             READIT
      CALL EXIT
                                                                              READIT
   16 IQUIT=0-
                                                                             READIT
      RETURN
                                                                              READIT
   17-K=IS(2)-
                                                                             -READIT
                                                                              READIT
      IA=3
    6 IF(K-1)102,19,20
                                                                              READIT
  102 WRITE(IOUT, 103)
                                                                              READIT
  103 FORMAT (21HOMISSING CONTROL CARD)
                                                                             READIT
                                                                              READIT
      CALL EXIT
                                                                              READIT
COMMENT-CARD-WAS READ
                                                                              READIT
   19 IS(1)=BLANK
                                                                              READIT
      IS(2)=BLANK
      WRITE(IOUT,500)(IS(I),I=1,72)
                                                                             READIT
      TINE=LINE+1
                                                                              READIT
      GO TO 18
                                                                            ---READIT
CALCULATE NUMERICAL DATA
                                                                              READIT
   20 NUM=0
      I-GN=0-
                                                                              READIT
                                                                              READIT
      DEC=0.
                                                                             -READIT
      -NUMB=0
                                                                              READIT
      KB=0
                                                                              READII
      ZEXP=0.
      DECP=0.
                                                                              READI1
```

	JZZ=0 LINE=0					READ
 4-1-	1F(K-8)41 0-1F(K-9)40					READ
40	2 MACH=32					READ
		Per bengangganggangganggangganggangganggangga	<u>Andre Coloren o Problem (Angres and Angres Colores) (Angres Angres and Angres and Angres Ang</u>	Marining and a share of the state of the sta	nima programma di Maria di Santania mana manda a dan pada tra mana da da mana da da mana tra mana da mana tra m	READ
40	RETURN 1 CALL EXIT				NETWORK MATERIAL CONTROL OF THE STREET PROPERTY OF THE WASHINGTON OF THE CONTROL WASHINGTON OF T	READ
- SI	EARCH-FOR-N	ILW-PROBLEM-	same son the description of the second section of the second seco	Pilopagani najan vilangan mandodi naga ang ang ang ang ang ang ang ang an		READ
		105) IS(1) , IS(2 -AST) 400 , 406 , 4			e transcompany and the second company of the second property and the second property and the second property a	READ READ
.40	5 FORMAT(2A	(1)				READ
40		2)/1073741824 -8)408,418,408		und de jaren i er und ste deller distablishe de de production de	maker industrial graph and graph ordered in the desired property of the control o	Principles and Control of Strategy of Strategy and Control of Strategy of Stra
40		-91400 				READ READ
TO AND DESCRIPTIONS		en Paulo de Plans Sangue, que esta esta sel sel sel sel sel sel sense à la constant de la constant de l'étable	addinativativativativativas dangaga or vivera dar da or vivera da da da da or vivera da or vivera da da da da d	r Zalanga kecampan pangangan mendapangan pengangan pengangan pengangan berangan berangan pengangan pengangan p	tipisanunkan dinasina kusunkagan di 1900 kilotokanan prisi tantan magaan situasa punyuk saat kis situan	Names common construction to all constructions of the Land
	appear, a serimon de transportant appear appear appear (a communication trade					
			Name and Associated Association of the Control of t			
Marketalecarage	Calculation of the strength of	ransalyik vintagan saarta aisa uu siiriyda van etkonalyykse saaria yddistyddistyddistyddistyddistyddistyddistyd	over upo reliation com em de construida de proprieta de la Persona de chiera de la recepción d	nette kannigin suutasia saista sainteen ehteen ja valan aasta apanasiin oli	enterente establica de la completa del la completa de la completa del la completa de la completa del la completa de la completa de la completa del la completa de la completa del la c	tides controlled to the state of
		and the second s	And the state of t		handrig en 186 augús ar un responso en 1884, con esta plante de caracter en 1886 a caracter en 1886 a caracter	0404M376000000000000000000000000000000000000
	and water the same of the same and the same					ate with the engage are and entered through expected
and supported the second supported the	Administración menten de destanción comorphismos de presidente destanda destanda se con presidente de presidente d	. Actor militer monthly to complete the complete transfer of the comple	, vers ere sæner ser ver en	NOT ALL COMMENTS AND	. Neperkkel mit er kent send som sin er kent fill som för film er som kan som kan som sin film er er en som som kan som kan som som kan som ka	1900 til State
	Marine dell'edit sur situati del contrata del contrata dell'edit dell'edit dell'edit dell'edit dell'edit dell'e					winetholdy.generous.compensation and analysis of the section of th
	,					What his spanners on the second second second
Municipal de Land de Garago	OZYMIĘJ WEŻNIAŚWYCĘ JOSE MAJOROWICZNIEŚ DYWIADOWY POWORZOWY JAKO KROWY	omen ur urtak rommen zen, kara kara kara kara kara kara kara kar	ude grande er vertre stelle kommunikasionska kinak høvet her flet er blev ste kryteringe fre en brye	omite wysiogania sografi, miesti się się się się się się się się się si	androdistring displays and a few last the control of the control o	terron and the state of the sta
	gamente de la companya del companya del companya de la companya de					Part Methods and a service of the service and a service an
				Managas and American American Commission of the		BACANSTRONGO APRILADA PARA A PARA ARTICA ARTICA DA
MARIE MANAGEMENT		Referencescopius (Dear-House Leatures Affrica Biography Constantin (Constantin France)	saktanisansisistekaikin keen keen kan kan keelisteksisteksisisteksisisteksisisteksisisteksisisteksisisteksisis	in and one of the second s	med transit de description and conference of the	Markethar state of the state of
	manusynn feitragad om prinsenpeldinkrig frikklungsgepterkinklundelse.		a salikusus siinitumaa keepeen saan kuu ku ka			Der versen og gregorier for der til der to der sterre for de
	анд Вал торм, штоб дават и и применен не применен получ у до уд. — ческого — в голового					antiferenting accounts you do not continue and continue accounts.
kaitumpia-takaana (discher (district der meiste gesett des (des der des		kandronada ini minda massi (contratano neumberana aranda minda di saste ang ang mananda di saste di saste di s	Protection of the security of		northinancy entre entre out of the control of the c
	maningan or a maning or maning and a maning and a second or a seco					And the state of t
	in the second se					and the second s
SALANDARY CHICAGONICANO	astar varidas in dinario communica de contractor de contractor de contractor de contractor de contractor de co	ernen ernen stemmer der der versteller erne stemmer den de versteller der versteller der versteller der verstelle	eon per metalle for the first communication and communication and communication and communication of the second	e de la company de la comp	skammigrake selatupan perikan selat selat mengangan penang selat selat selat selat selat selat selat selat sel Selat selat se	Photocological photocologic region of the conference
-	ng ngamatan sa gagagang na pa a pa da ta gagan a pa natan manan		Performance and the second		. Makinga dibinan junis ing mangunan dan persangan sang banjan di Midding, miya manin menge	allen medicale regularies and the control of the co
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				· · · · · · · · · · · · · · · · · · ·		
Manufacture of the second	-	and an extension of the second	description has produced access and was an extensive constitution of the second state	Marie Caracter Control of the Contro	·····································	Authoritische Propertiese von der Gertrieber von der Gertrieben der Vertrieben der Vertrieben der Vertrieben d

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$JOB 1202C003 427 NOCJA NOO01B1270
SEXECUTE
                IBJOB
$-IBJ0B-
               MAP FIOCS
SIBFTC NUMBER LIST, DECK, DD, XR7
     - SUBROUTINE NUMBER (KB)-
                                                                                NUMBER-
C
                                                                                NUMBER
      -COMMON -- Z--
                                                                                NUMBER-
      DIMENSION Z(16000), I2(200), N2(200), P2(200), I3(1600), N3(1600), P3(
                                                                                NUMBER
     NUMBER-
     3P6(600), 16(600)
                                                                                NUMBER
      EQUIVALENCE (Z(2);IOUT);(Z(4);K);(Z(5);NUM);(Z(6);IGN);(Z(7);DEC);
                                                                                NUMBER
     2(Z(8), NUMB), (Z(9), ZEXP), (Z(10), DECP), (Z(11), LERR), (Z(13), LINE), (Z(
                                                                                 NUMBE
     33575), I2(1)), (Z(<del>3375), N2(1), P2(1)) , (Z(828), J2), (Z(829), J3),</del>
                                                                                NUMBER-
     4(Z(830),J4),(Z(831),J5),(Z(832),J6),(Z(5379),I3(1)),(Z(3779),N3(
                                                                                NUMBER
     -5-1-)-)-y-(-Z-(-3-7-7-9)-y-P-3-(-1-)-)-y-(-Z-(-1-0000-)-y-P-4-(-1-)-)-y-(-Z-(-1-1-8-30-)-y-P-4-(-1-)-)-y-(-Z-(-1-1-8-30-)-y-
                                                                                NUMBER **
     6N4(1)),(Z(6991),N5(1)),(Z(6991),P5(1)),(Z(7721),I5(1)),(Z(8451),
                                                                                NUMBER
     7N6(1)),(Z<del>(8451),P6(1)),(Z(9051),16(1)),(Z(9651),1);(Z(9652),TEMP),</del>
                                                                                NUMBER-
     8(Z(9653), TEM), (Z(9654), TEMA)
                                                                                NUMBER
      -SET ERROR RETURN FOR NO ERROR
                                                                                NUMBER-
      LERR=0
                                                                                NUMBER"
      CHECK FOR NUMBER OR Z
                                                                                NUMBER
                                                                                NUMBER-
    7 IF(KB)100,3,6
    6 I = -1
                                                                                NUMBER
      GO TO 5
                                                                                NUMBER
      DETERMINE TYPE OF NUMBER
                                                                                NUMBER
    3-1F(DEC)100,1,2
                                                                                NUMBER"
  100 WRITE(IOUT, 101)
                                                                                NUMBER
  101 FORMAT (24HOMACHINE ERROR IN NUMBER)
                                                                                NUMBER-
      LERR=1
                                                                                NUMBER
     ---RETURN----
    1 IF(IGN)2,4,2
                                                                                NUMBER
    - FIXED POINT NUMBER, SET SIGN
                                                                                NUMBER*
    4 NUMB=NUM*NUMB
                                                                                NUMBER
     ···[=0----
                                                                                NUMBER-
      GO TO 5
                                                                                NUMBER
     -FLOATING-POINT NUMBER, COMPILE PIECES
                                                                                NUMBER-
    2 TEMP=NUMB
                                                                                NUMBER
      T-EM=NUM---
                                                                                NUMBER
      TEMA=IGN
                                                                                NUMBER
      -PNUMB=(TEMP+DECP)*TEM*10.**(TEMA*ZEXP)
                                                                                NUMBER
                                                                                NUMBER
      BRANCH TO TYPE OF INPUT AND STORE
                                                                                NUMBER
    5 GO TO (100,12,13,14,15,16),K
                                                                                NUMBER
                                                                                NUMBER
   12-J2=J2+1---
   18 IF(201-J2)102,102,17
                                                                                NUMBER
                                                                                NUMBER
  102 WRITE (10UT, 103)K
  103 FORMAT(2HO*I1,45HTABLE OVERFLOW - YOU JUST KAUNT USE THIS MUCH)
                                                                                NUMBER
      LERR=1
   19 RETURN
                                                                                NUMBER
   17-12(J2)=I
                                                                                NUMBER
                                                                                NUMBER
      IF(1)19,20,21
                                                                                NUMBER
   20 N2 (J2) = NUMB-
      GO TO 19
                                                                                NUMBER
                                                                                NUMBER
   21_P2(J2)=PNUMB
                                                                                NUMBER
      GO TO 19
                                                                                NUMBER.
       J3=:J3±1
                                                                                NUMBER
   22 IF(1410-J3)102,102,23
```

Markey Sections of the Control of th		
. 4	5 IF (DEC) 46,47,147	
4	6 MACH=45	READIT
	GO TO 100	READIT
- 4	7-NUMB=NUMB*10 GO TO 21	READIT READIT
3 /.	OU 10 21 7_DEC=DE-C-K-1-O	KEAUII
Calendar and Assessment of Control of Contro	GO TO 21	A STANDARD AND AND STANDARD AND AND AND AND AND AND AND AND AND AN
_ CHEC	← NEXT-VALUE FOR BLANK	READIT
- 205.590.	4 IF(72-I)49,62,61	READIT
	9-MACH=44	READIT
	GO TO 100	READIT
<u> </u>	4-min J-Fr (n J-Zom Jn) of n Gry of a left Garage Inter Commence and the commence of the comme	es para la partir de la companya de
. 14	5 ZEXP=NUMB1	
-	-GO-TO-201	<u>almentiti (1884) ung makumana kan mentin Palmentpunyan dikut Spatin Hithy tilaj (paman unanterkonik</u>
	6 ZEXP=NUMB1	
	-IF(IS(I+1-)-BLANK)163,200,163	adds allundann da gweigne (geongad an dingeles diwat hae ye endy de greek benede da gweinn diwat en diwat diwa O
24.38	3 IF(IS(I+1))189,64,64	
10 PAGE -	9-1F-(-I-5-(-I-+-)-)-2-2-1-2-9-9-2-9-2-9-2-9	DEVDIT
6	2 ZEXP=ZEXP*10. 	READIT READIT
	1 IF(IS(I+1)~BLANK)63,200,63	READIT
.4	3- IF(IS(I+1)) 189,62,64	
	4 TEMP=IS(I+1)/1073741824	
7 mg		**************************************
	GO TO 200	READIT
CHEC	K-FOR-Z	READIT
8	9 IF(IS(I)-ZZ)29,92,29	•
9	2-IF(NUM)93,90,93	· promption of the first control of the profession on the profession of the first o
	3 CALL NUMBER(KB)	
9	Chance K - Barrier I concentration to the contration of the contra	READIT
	GO TO 34	READIT
	K-FOR PLUS	READIT READIT
. 193.	2 IF(IS(I)-PLUS)72,73,72 LUS OR E FOUND - SET EXPONENT	READIT
- J -	3 IGN=1	. READIT
	TOWN T	READIT
	K FOR E, IT WAS NOT PLUS	READIT
	2 IF(IS(I)=E)74,73,74	READIT
	K FOR DECIMAL POINT, IT WAS NOT E	READIT
7	4 IF(IS(I)-DOT)76,75,76	READIT
1 -	ECIMAL - SET VALUE	READIT
on downware		READIT
· · · · · · · · · · · · · · · · · · ·	GO TO 21	READIT READIT
		READIT
	6 IF(IS(I)-10737418240)77,29,89 K-FOR-TYPE-OF NUMBER AND SET ACCORDINGLY	READIT
CHEC	7 IF (IGN) 144, 177, 144	READII
0.0003	7 IF (16N/14491/19144 7 IF (DEC) 78279:80	er Services sometiment og Compressionamentersentersent en som i 1800 er 1808 ble 1808.
2000000	8 MACH=77	READI1
	-GO-TO-100	READI1
	9 NUMB=10*NUMB+NUMB1	
	<u> </u>	READI
8	O DEC=DEC*10.	READI
PGS SECTIONS TO SECURITION OF	ANGERON TO EMPREN NUMBA] AS THE OF THE OWNER OWN	in the state of th
	DECP=DECP+TEMP/DEC	READI
2	1-00/11/10/2	READI
	IF(NUM)201,303,201	י ארו אי
	1 CALL NUMBER (KB)	READI
	3 IF(LERR)18,18,32	READI
0.038	2 WRITE(10UT9420) O FORMAT(1H1)	READI
	U. CARSTON CALIFIED.	ハニハレエ

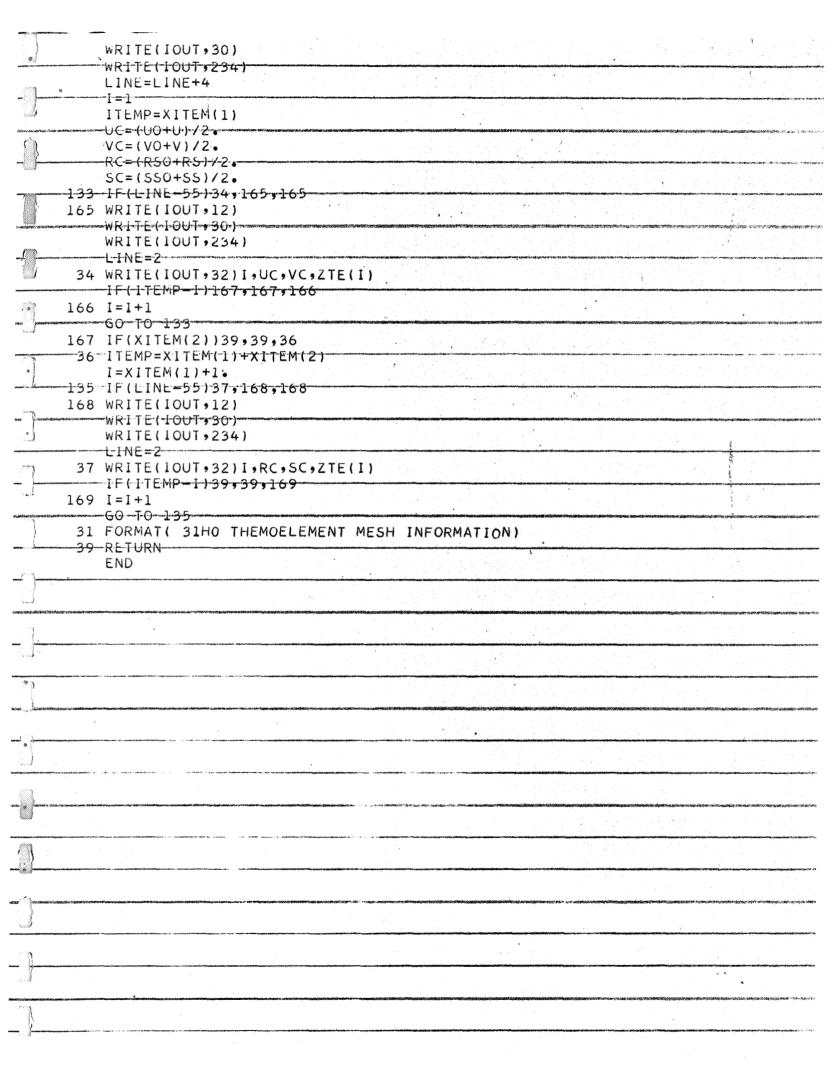
	DO 21 1=IA,72	READIT
	155(1)=15(1)	READIT
	NUMB1=IS(I)/1073741824	
	FOR PROCESSING A NUMBER	READIT
	IF(NUM)25,24,25	READIT
347579%	FOR-BLANK NOT A NUMBER	READIT
893330	IF(IS(I)-BLANK)26,21,26	READIT
	FOR MINUS - NOT BLANK, ITE=-1 IF -0; =0 IF +0; = +1 OTHERWISE	READIT
26	IG=IS(I) CALL CHECK(IG; ITE)	
	IF(ITE)91,21,28	READIT
manufact to have	INSMINUS, SET SIGN	READIT
	IF(IS(I)-ZZ)29,92,30	1,2,7,5
565668	VANCET.	READIT
	GO TO 21	READIT
-CHECK	FOR + OR	READIT
28	IF(IS(I))89,728,628	READIT
7-2-8-	-MAGH-28	READIT
	GO TO 100	READIT
- CHECK	FOR LEGALITY OF POSITIVE IS, FIRST DECIMAL POINT	READIT
628	IF(IS(I)-DOT)36,37,29	READIT
-29	-1-G=1	READIT-
* James	DO 327 IH=IG,72	READIT
3.2-7	$-I_{-}SS \cdot (-I_{-}H_{-})-I_{-}S \cdot (-I_{-}H_{-})$ the the second contract of the second co	READIT
	WRITE(IOUT,500)(ISS(IH),IH=1,72)	
	WRITE(IOUT,31)	READIT
31	FORMAT(50HOYOU GOOFED - ILLEGAL CHARACTER ON PRECEDENCE CARD)	READIT
- CHECK	FOR NEW PROBLEM	READIT
,	GO TO 32	READIT
- June 307	ECT Temporaries and the second contract of th	READIT
7	NUM=1	READIT
1227.00	-GO-TO-21	READIT
	NEXT NUMBER	READIT
	-IF(NUMB1-10)33,29,38	Whitepayare representation to any over recovered the
	IF(IS(I)-PLUS)29,21,29	READIT
	DLUSET-ANDOSTORAGEOGEGEGTTIMATEUNUMBER	READIT
	NUM=1	READIT
	NUMB=NUMB1 GO TO 21	READIT
CUECK	FOR BLANK IN NUMBER BEING PROCESSED	READIT
	IF(IS(I)-BLANK)89,34,35	READIT
,	ANK-FOUND-END-OF-NUMBER	READIT
	CONTINUE	READIT
	CALL NUMBER (KB)	READIT-
. (1)	NUM=0	READIT
	IGN=0	READIT-
800	DEC=0.	READIT
an limitinamen		READIT
	KB=0	READIT
	-ZEXP=0.	READIT-
	DECP=0.	READIT
	-GO-TO-21	READIT
CHECK	FOR MINUS, IT WAS NOT BLANK	READIT
		READIT
	IF(ITE)40,41,42	READIT
——————————————————————————————————————	NUS FOUND - SET AS EXPONENT	READIT
	IGN=-1	READIT
- }	GO TO 21	READIT
CHECK	FOR EXPONENT SINCE IS CONTAINS ZERO	READIT
	multiple (mile (mile (mile) - the first of t	READIT
CHECK	FOR DECIMAL - IT WAS NOT EXPONENT	READIT
A		NOTICE AND A CONTRACTOR OF THE PROPERTY OF THE

	23, 13(J3)=I	NUMBER
52000	IF(I)19,24,25 24 N3(J3)=NUMB	NUMBER
- `	60 70 19	- NUMBER
	25 P3(J3)=PNUMB	NUMBER
	G_0 T_0	NUMBER NUMBER
- }	26-I+(731-J4)102,102,27	NUMBER
	27 I4(J4)=I	NUMBER NUMBER
	IF(I)19,28,29 28 N4(J4)=NUMB	NUMBER
ON THE PROPERTY OF THE PROPERT		NUMBER
_	29 P4(J4)=PNUMB	NUMBER NUMBER
	15 J5=J5+1	NUMBER
22.7200s	30 IF (731-J5)102,102,31	NUMBER
and Primolacizano	31 Ib(J5)=I	NUMBER NUMBER
4,3) '	32 N5(J5)=NUMB	NUMBER
	- GO TO 19	NUMBER NUMBER
	33 P5(J5)=PNUMB	NUMBER NUMBER
, err eng	16 J6=J6+1	NUMBER
MAT WAR ACCOMPANY OF	34 IF (-601 J6)-102, 102, 35 35 I6(J6)=I	NUMBER NUMBER
	$\frac{35 \cdot 16(36) - 1}{15(1) \cdot 19 \cdot 36 \cdot 37}$	-NUMBER
	36 N6(J6)=NUMB	NUMBER
	GO TO 19 37 P6(J6)=PNUMB	NUMBER NUMBER
santor o prosinavida	31 FO(JO) FOUTD	NUMBER
	END	NUMBER
		
_ \	"我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的,我们就是我们的,我们就会不会的。""我们的我们,我们是最好的。""我们就是我们的,我们就是我们	
-6		
j		agyangan waga nasagangan gadamatakan ang an atautah maga menanahan n Bangan ang ang ang ang ang ang ang ang an
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SIBFTC FPMAP
                               LIST, DECK, REF, DD, XR7
            SUBROUTINE FPMAP (CENX) CENY, NOD, XPRNT, YPRNT, IX; L2)
            COMMON Z
            DIMENSION 2(20000), IB(100), IE(100), XITEM(2), CENX(IX, L2),
          1CENY(IX, L2), ZA(200), ZTE(100 ), XPRNT(IX, L2), YPRNT(IX, L2),
          2PRNT(1-13-), NOD(IX, L2)
            EQUIVALENCE (Z(6116), IB(1)), (Z(6216), IE(1)), (Z(5200), LB),
          -1 (ZA(166), XITEM(-1)),
          2(Z(627), ZA(1)), (Z(2), IOUT), (Z(11), LERR),
          3(Z(17316),ZTE(1)),-
          4(Z(5425), UC), (Z(5426), VC),
          ·5(Z-(-543·1-----)。·I-TEMP-)。·(-Z-(-542-7------)。·RS-)。(Z-(-541·8-)。·THE-)。·(-Z-(-541·7-)。·I-J-)。·
          6(ZA( 2
                               ) 9 Y ) 9
                                           --(Z(5415),II),(Z(5429),XS),(Z(5430),YS),
          8(Z(5414),DY),(ZA(1),X),(Z(5413),DX)
          - EQUIVALENCE----
                                                         ----(Z(5716-),PRNT(1)),(Z(5410),B),
          1(Z(5409),D),(Z(5408),C),(Z(5407),G),(Z(5406),LINE),
          3(Z(5400),J),(Z(5428),NT),(Z(5432),NODA),(Z(5211),DELX),
         -4(ZA(4),60),-(ZA(5),VO),(ZA(6),60),(ZA(7),V)
                         LANK, JPR, MINU, MINI/1H, 1HX, 1H-, 1HI/
            INTEGER PRNT, XPRNT, YPRNT, XPRN, YPRN
      12 FORMAT(1H1)
     10-FORMAT(1H-,112A1,14)-
      11 FORMAT( 32H1COLLECTOR AND RADIATOR NODE MAP/112H0 1234567891111111
          301X,11H01234567890)
      13 FORMAT(1H0,5X,3HMAP,12X,3HX-Y,18X,
                                                                                                               14X,4HNODE)
  -235 FORMAT(12H-COORDINATES;5X;11HCOORDINATES;12X;
          INUMBER)
    -30 FURMAT (3X,4HNODE,13X,5HX-Y-Z)
    234 FURMAT (8H NUMBER, 10X, 11HCOORDINATES)
     -32 FORMAT(16,3E12,5)----
      18 FORMAT(216,2E12.4,17)
       ---- RSO=0. ~
            RS=0.
            SSO=0.
            SS=0:
          -XITEM(2)=0- --
             IMAX=XITEM(1)
           -ZTE(-1)=DELX/-2---
            DO 801 I=2, IMAX
                                                                                              2 18
      --- ZIE(I)=ZTE(I-1)+DELX-
    801 CONTINUE
          --NODA=XITEM(1)+<del>XITEM(2)</del>
                                                                                            Carpert Wall
            NT = 1 + NODA
            DO-1020-J=1-tB
                                                                                            WILLIAM ST
             IA=IB(J)
             IC=IE(J)
            DO 1021 I=IA,IC
            TN=(C.1)-CON-
  1021 NT = NT + 1
  1020-CONTINUE
            NT = NT + 1
            LL=LB+1-
             LU=2*Lb
            DO-1022 J=LL,LU
             IA = IB(J)
             a factoria for the factoria for the factorian fo
             DO 1023 I=IA,IC
                                                                                      1.00
                                                      5 ( 5 )
```

```
IN=(L,I)GON.
1023 NT=NT+1
1022 CONTINUE
111 WRITE (TOUT,11)
     LINE=5
    G=ABS((VO-V)/10.)
     C = (VO + V)/2
    D=(U0+U)/2.
     B=ATAN(C/D)*57.296
    DO-24-1=1,111
     PRNT(I+1)=MINU
 24 CONTINUE
  26 PRNT(1)=MINU
    PRNT (113)=0--
    WRITE (IOUT, 10) (PRNT(II), II=1, 113)
    PRNT(113) = 1
  27 PRNT(1)=MINI
    PRNT(112)=MINI
    DX=X/110.
   - DY=1.71*DX-
     YS=Y+DY
   -- I J=1-----
 112 YS=YS-DY
 ----XS=-DX--
     II=1
103-XS=XS+DX-
     J=1
-1-02--I=IB(J)-----
 101 IF(ABS(YS-CENY(I,J))-DY)1201,201,200
200 PRNT(II+1)= LANK
   ---GO-TO-1-
 201 IF(ABS(XS-CENX(I,J))-DX)1202,202,200
1202 IF (XS.LE.CENX(I,J)) GO TO 202
     GO TO 200
202 PRNT-(11+1)=JPR-
    XPRNT(I,J)=II
    -U-- (-U-- )-TMR9Y-
    GO TO 3
  -1-IF(-I-IL(J))104,2,2-
 104 I = I + 1
   2 IF(J-LB)105,3,3
-105-J=J+1----
     GO TO 102
  -3 IF(II-110)106,107,107-
 106 II=II+1
  107 WRITE(10UT,10)(PRNT(II),II=1,113)
    -PRNT(113)=PRNT(113)+1-
     IF(YS)4,4,108
 108-IF(LINE-55)110,109,109
 110 LINE=LINE+1
113-1-1-1-1
     GO TO 112
 109 WRITE(IOUT, 11)
     LINE=5
    GO TO 113
   4 I = 1
     00 - 339 - I = 1 + 112
 339 PRNT(I)=MINU
```

```
PRNT(113) = 0
    WRITE (IOUT, 10) (PRNT(I), I=1,113)
 41 IJJ=IJ
IF(LINE-30)124,123,123
123 WRITE (IOUT, 12)
---EINE=0
124 WRITE(IOUT, 13)
----WRITE(IOUT, 235)
    LINE=LINE+3
   -I J = 1 -
122 II=1
121-J=1-
120 I=IB(J)
119-IF(XPRNT(I,J)-II)16,116,16
116 IF(YPRNT(I,J)-IJ)16,117,16
117-IF(ABS(CENX(I,J)-D)-1.0E-4)118,118,156
156 THE=ATAN((CENY(I,J)-C)/(CENX(I,J)-D))*57.296-B
----IF(-CENX(-I-, J)-D)321-321-322
321 IF(CENY(I,J)-C)328,330,324
330-IF(CENX(I,J)-D)324,324,131
324 THE=THE+360.
----GO TO 323-
328 IF(THE)324,323,323
322-IF(CENY(I-, J)-C)-340-330-340
340 THE=THE+180.
-323 GO TO-315-
118 THE=ATAN(D/C)*57.296
-130-IF(CENY(-I+J)-C)315+131+131-
131 THE=180.+THE
315-CONTINUE-
 15 THEP=THE/57.296
 ----IF(ABS(CENY(I,J)-C)-G)150,150,151
150 RS=(CENX(I,J)-D)/COS(THEP+B)
----GO TO 17
151 RS=(CENY(I,J)-C)/SIN(THEP+B)
RS=ABS(RS)
 17 CONTINUE
 ---IF(LINE-55)153,152,152
152 WRITE(IOUT, 12)
  --- WRITE (IOUT , 13)
    WRITE (IOUT, 235)
153 WRITE(IOUT, 18) II, IJ, CENX(I, J), CENY(I, J),
                                                     NOD(I,J)
   LINE=LINE+1
    GO TO 158
-16-IF(IE(J)-I)155,155,154
154 I = I + 1
 ---GO-TO-119-
155 IF(LB-J)158,158,157
157-1=1+1-
    GO TO 120
158-IF(110-II)159,159,160
160 II=II+1
 159 IF(IJJ-IJ)23,23,161
161-IJ=IJ+1-
    GO TO 122
 -23-IF(LINE-30)162,163,163
163 LINE=0
   WRITE (JOUT 912)
162 WRITE(IOUT,31)
```



```
SIBFTC PRO2 LIST, DECK, DD, XR7
      SUBROUTINE PRO2
                                                                                       PRO2
                                                                                       PRO2
      COMMON Z
                                                                                       PRO2
      EQUIVALENCE (Z(2), IOUT), (Z(11), LERR), (Z(3575), T2(1)), (Z(3375), N2(
                                                                                       PR02"
                        (Z(614),M1),(Z(615),M2),(Z(616),M3),(Z(617),M4),
                                                                                       PR<sub>02</sub>
     3(Z(618),M5),(Z(619),M6),(Z(620),M7),(Z(621),M8),(Z(622),M9),(Z(623
                                                                                       PRO2
     4),M10),(Z(624),M11),(Z(625),M12),(Z(626),CTH),(Z(627),ZA(1)),(Z(82
                                                                                       PRO2
     58),J2),(Z(3375),P2(1)),(Z(614),MA2(1)),(Z(3763),MS(1)),(Z(3762),I)
                                                                                       PRO2
                                     ,(Z(3760),NA),(Z(3759),NZ)
     6,(Z(3761),N)
      DIMENSION Z(16000)
                                                                                       PR<sub>0</sub>2
      DIMENSION I2(200), N2(200), P2(200), ZA(200), MS(12), MA2(12)
                                                                                       PRO<sub>2</sub>
      NAMELIST /NAM1/CTH/NAM2/ZA
      M6 = 0
      DO 170 I=1:12
                                                                                       PRO2
                                                                                       PRO2
      MS(I) = MA2(I)
                                                                                       PRO2
  170-MA2(I)=0--
                                                                                       PR<sub>0</sub>2
      LERR=0
     -- I = 1-----
                                                                                       PRO2-
                                                                                       PRO2
   17 IF(I2(I))13,14,31
                                                                                       PRO2-
   -13-WRITE(-10UT-15)--
   15 FORMAT(27HOILLEGAL CONTROL IN *2 DATA)
                                                                                        PRO2
   30-LERR=1-
   25 RETURN
                                                                                       PRO2
   14 IF(N2(I)-1)13,1,16
                                                                                       PRO2-
   16 IF(12-N2(I))13,12,18
   1-8-N=N2(I)
                                                                                       PRO2
                                                                                       PRO2
   34 GO TO (100,2,3,4,5,6,7,8,9,10,11,12),N
                                                                                       PRO2-
  100-WRITE(10UT,101)
  101 FORMAT (32HOMACHINE ERROR - SUBROUTINE PRO2)
                                                                                        PRO<sub>2</sub>
      -GO-TO-30-
    1 I = I + 1
                                                                                        PRO2
   -36--IF(-I-2(-I-)-)-19-,20-,21
                                                                                       PRO2
                                                                                       PRO2
   19 IF(I-J2)22,26,27
                                                                                       PRO2-
   22 I = I + 1 - - - -
                                                                                        PRO2
   24 IF(I2(I))19,14,31
                                                                                       -PRO2-
   20 CTH=N2(I)
                                                                                        PRO2
      M1 = 1
                                                                                       PRO2
     -GO-TO-1-9-
                                                                                        PRO2
   21 CTH=P2(I)
                                                                                       PRO2
     -- M1=1----
                                                                                        PR<sub>0</sub>2
       GO TO 19
                                                                                       PR02
  175 IF(M1)100,27,28
                                                                                        PRO2
   27 WRITE(IOUT, 29)
   ~29-FORMAT(43H0INSUFFI<del>CIENT-*2-DATA---I-CANNOT-DO-P-OB</del>LEM)
                                                                                       PRO2
                                                                                        PRO2
      GO TO 30
                                                                                       PRO2
   31 IF(P2(I)-1.)13,1,32
                                                                                        PR<sub>0</sub>2
   32 IF(12.-P2(I))13,12,33
                                                                                        PRO2
   33-N=P2(I)
       TEMP=N
                                                                                        PRO2
                                                                                        PR02
   35 IF(P2(I)-TEMP)13;34;13
                                                                                        PRO2
   28 IF(N2)100,27,37
                                                                                        PRO2
   37 IF(M3)100,39,38
                                                                                        PRO2
   39 IF(M4)100,27,40
                                                                                        PRO2
   38 IF (M4) 100, 40, 41
                                                                                        PRO<sub>2</sub>
   41 WRITE(IOUT, 42)
                                                                                        PRO2
   <del>42 FORMAT(41HOTOO MUCH *2 DATA - IT CONTRADICTS - GOOF)</del>
                                                                                        PRO2
       GO TO 30
```

			NAME OF THE PERSON OF THE PERS
14 0000	4.0	15 (ME) 100-42-44	PRO2
- J		IF(M5)100,43,44 IF(M6)100,27,45	PRO2
		IF(M6)100,45,41	PRO2
3		IF (MO) 100, 43, 41	PRO2
T		IF(M8)100,27,47	PRO2
,,,,			PRO2
)		-IF (M9)-100-27-48	PRO2
1		IF(M10)100,27,49	PRO2
		IF(M11)100,27,79	11102
entra.		IF(M12)100,27,200	MANAGER SER MES COMMUNICATION IN COMMUNICATION
- 1		IF(M6)80,201,80	
		M6=M60	Specialis
SEOPLE OF THE SEA		IF(M7 - M6)67,81,67	
111		IF(M9-M6)67,82,67	entre de la constante de la co
7,		IF(M1U-M6)67,83,67	
elcode.	-	IF(M3)100,116,115	-PRO2
27%		IF(8+M6-M11)67,117,67	PRO2
		IF(12+M6-M11)67,117,67	***PR02
ust Journe		1F-(M11#1000)118;119;119	PRO2
		WRITE(IOUT, 120)	PRO2
	120	FORMAT (31HOTOO MANY MESH POINTS SPECIFIED)	PRO2
	, , ,	GO TO 30	rangementer etteratura
***************************************	-118	CONTINUE	
-		RETURN	-PRO2-
38.			PRO2
		NZ = 3	PRO2
)	E O	M2=1 NO F3 II = NA - N7	PRO2
		DO 53 II=NA,NZ	-PRO2
,1		I=I+1 IF(I2(I))54,55,56	PRO2
NAME OF THE OWNER.		-2A(-I-I)=N2(-I-I)	PRO2
13		GO TO 53	PRO2
		ZA(II)=P2(I)	-PRO2
	70	GO TO 53	PRO2
		WRITE (IOUT, 58)	-PRO2
		FORMAT (20H0IMPROPER Z LOCATION)	PRO2
NAME OF TAXABLE PARTY.			PRO2
	53	CONTINUE	PRO2
		GO TO 19	PRO2
Samuel	3	NA=4	PRO2
		NZ=7	PR02
1		M3=1	PRO2
w.ministra	AND THE PROPERTY OF THE PROPER		distribution in activities of the state of
v.		GO TO 59	PRO2
	4	NA=4	PRO2
	•	NZ=11	PRO2
***************************************		-M4=1	PRO2
7		M60=2	
	remaining provides and a second	-GOTO-O	PRO2
anguigit*	5	NA=12	PRO2
/ in		IF(I2(I+2))60,61,61	
	60	NZ=12	PRO2
		M5	PRO2-
7 p. 60m		GO TO 59	PRO2
2000		a.NZ = 1.3 is the processing of the processing of the process o	PRO2
J		M5=2	PRO2
	-	-GO-TO-5·9	PRO2
	6	NA=14	PRO2
- }-		-DO-62-II-=1-40	
· 2000		JA=I+II+1	PRO2
SECTION SECTION	gariana especial de la compositione	may J. Fr. (a. J. Ze (v. J. Apr) a). 6-2-yo C 2 ay G. 2 are a second and a second a second and a	PRO2
	63	NZ = NA + II - 1	PRO2

```
M6 = (NZ - 13)/2
   GO TO 59
62 CONTINUE
   M6=20
   GO TO 59
   NA=54~
   DO 64 II=1,20
   JA=I+II+I
   IF(I2(JA))65,64,64
65-NZ=NA+II-1-
   M7=NZ-53
   -GO-TO-59
64 CONTINUE
   -M7 = 20
   GO TO 59
67 WRITE (IOUT , 68)
68 FORMAT (31HOINCONSISTENT *2 DATA - TCH TCH)
   -60-TO-30
 8 M8 = 1
   NA=75-
   NZ = 77
   -GO-TO-59-
 9 NA=78
   DO 69 II=1,40
   JA=I+II+1
   IF(I2(JA))70,69,69
70 NZ=NA+II-1
   -M9=(NZ<del>-77)/2</del>
   GO TO 59
69-CONTINUE
   M9 = 20
   GO-TO-59-
10 NA=118
   DO 72 -1 I=1,40
    JA=I+II+1
   -IF(-I2(UA))73,72,72
73 NZ = NA + II - 1
   -M10 = (NZ - 117)/2
   GO TO 59
72-CONTINUE
   M10 = 20
   GO TO 59
11 NA=158
   DO 90 II=1,32
    JA=I+II+1
    IF(I2(JA))91,90,90
91 NZ=NA+II-1
    M11=NZ-157
    GO TO 59
90-CONTINUE
    M11 = 32
    GO-TO-59
 12 NA=190
   -NZ=193-
    M12 = 1
    -GO-TO-59--
 26 IF(M1)100,171,172
171-M1=MS(-1-)--
172 IF(M2)100,173,174
173-M2-MS(2)-
174 IF(M3)100,176,179
```

		IF (M4)1		179								PRO2
	-178 •	M3=MS(3) M4=MS(4))		And the latest and the second of the second		**************************************	ezanyandyarkushiyi noop e, eski yiki daray oo karee	ing and conference to the construction of the Conference of the Co	paraksis salikan in Salaksis Paraksis karaban salikan salikan salikan salikan salikan salikan salikan salikan	anganako elemparako harra elemparako el	PRO2 PRO2
7.	179 182	DO 180 IF(MA2(I = 5, 12		- Washington Commission (Commission Commission Commissi	***************************************			and the second s	udarente primero en escribirativo de primero de ch	Management and specific company of the company of t	PRO2 PRO2
	181	MA2(I)=	MS (-I-)	e Propins Principle Constitution of the Principle Constitution of	and the state of t	DES EL PRO SON GENERALISMO ENTRE PROPERTIE DE SERVICION D	tandi mate in considerate mercina professione	eneministration of the section of th	aheesta kasuus oo ka		THE THE STATE OF T	PRO2 PRO2
)	100	GO TO-1	75	ing makeun du "bas in grande sande vertice van 'n basis een salde ande		and the second section of the sectio	The second district of	idanista saligua militaria de la cale	SANTAN AND AND AND AND AND AND AND AND AND A	a vedisavidnojih visa da ve pa daljim kir samutukti.	ngas polatica servicians servicinos de secucionas com pres	PRO2 PRO2
- F3	ORIG		ALPHA	and the second s			***************************************		igeacure Corp., provinciar a rooth a -		tajoa urusin kalendaria	FRU2
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-17-	erikansı iş dir. di dikin bir bir bir bir bir bir bir bir bir bir	his	nine and the second of the second	a apartery the acquisit of the second state of the second state of the second state of the second state of the					(1800)	nd de la	Han bistorin sakrapent arkapani kemuda dinakan ke	kasaatinaajattaatatakka siinnaan yotis
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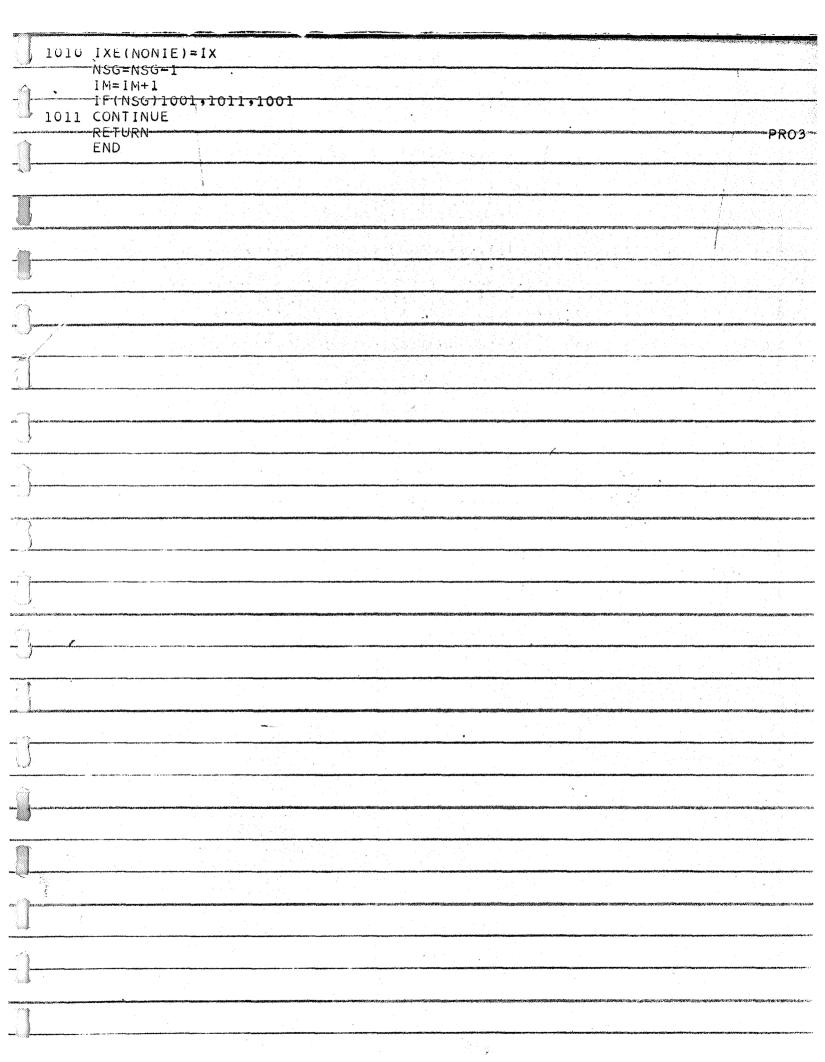
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- s	IBFTC PRO3 LIST, DECK, DD, XR7	former man in the second of th
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Î	DIMENSION Z(20000), TES(200), ALPHAS(200), THERMS(200), RESIS(200),	PRO3
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Anthodolikou marin	EQUIVALENCE (2(12), IPR), (2(832), MACH), (2(11), LERR), (2(833), TES(1)	7PR03-
بسر	2,(Z(1033),ALPHAS(1)),(Z(1233),THERMS(1)),(Z(1433),RESIS(1)),(Z(PRO3
__\	31633), CAPS(1)), (Z(1833), DENS(1)), (Z(2033), EPSIS(1)), (Z(2233), ICS(PRO3
	41)),(Z(2433),ITAB(1)),(Z(2443),NP3),(Z(8589),IZC(1)),(Z(8579),	PRO3
	51ZD(1)),(Z(8379),1C(1)),(Z(8179),TE(1)),(Z(7979),ALPHA(1)),(Z(7777	
()	6) THERM(1)), (Z(7579), RESIST(1)), (Z(7379), CAP(1)), (Z(7179), DEN(1))	
1	7 (2(6979) EPSI(1)), (2(5379), 13(1)), (2(3779), P3(1)), (2(3779), N3(1))	n to despression production descriptions and construction of the c
	8,(Z(3778),I),(Z(3777),N),(Z(3776),TEMP),(Z(3775),IP),(Z(829),J3)	PRO3
	9(Z(13661),1ZA(1)),(Z(2),10UT)	, , , , , , , , , , , , , , , , , , ,
Į	EQUIVALENCE (Z(17416), IXB(1)), (Z(17436), IXE(1)), (Z(627), ZA(1)),	
	1(ZA(54), MATTE(1))	
	NAMELIST/NAM1/TES/NAM2/ALPHAS/NAM3/THERMS/NAM4/RESIS/NAM5/CAPS/	
4		CONTRACTOR OF THE PROPERTY OF
-	INAM6/DENS/NAM7/EPSIS/NAM8/ICS LERR=0	PRO3
2		PR03
eria.		PRO3
	IPR=1	PRUJ
	1- IF (NP3) 2-, 205, 4	DD02
	2 MACH=1	PRO3
~	100 WRITE(-10UT-) 101-) MACH	
- Y	101 FORMAT (32HOMACHINE ERROR, PRO3, STATEMENT 14)	PRO3
Parameter State Control	GO TO 8	0003
. 4	4 DO 5 I=1, IPRO	PRO3
_	-Z(I+9799)=IES(I)	PRO3
	Z(I+9599)=ALPHAS(I)	PRO3
same management d	$Z-(-I-+9399)$ is THE RMS (ω John francous and ω	PRO3
	Z(I+9199)=RESIS(I)	PRO3
->	-Z(I+8999)=(APS(I)	PRO3
1,51 (44	Z(I+8799)=DENS(I)	PRO3
		PR03
1	5 IZA(I)=ICS(I)	PRO3
www.iiiidaww	ser Sylver O O may the major to the form management of the service	nemental substitution of the substitute of the s
	IZC(I)=ITAB(I)	PRO3
- 4-	IZD(I)=0	PR03
1	94 ITAB(I)=0	PRO3
	$3 \cdot 1 \cdot 1$	PRO3
6	21 IF(I3(I))6,15,10	PRO3
and James	CONTROL OF THE CONTRO	PRO3
100	7 FORMAT(20H0ILLEGAL CONTROL, *3)	
	9 RETURN	PRO3
	-10-IF(P3(I)-1.6)6,11,12	PR03
	12 IF(P3(I) - 6.)13,11,6	
man Laure	3-4-1-1-2-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	PR03
1	TEMP=N	PRO3
~»	IF (ABS (P3 (I)-TEMP)-+01)110+110+6	
.~	11 N=P3(I)	PRO3
1	11 N-F3(1) -110-IC(IPR)=N	———PRO3
- 5	GO TO 14	PRO3
	50 10 14 	FRO3
•		1 1103
	17 IF(N3(1)- 6)16,16,6	randoma and the state of the st

	16	IC(IPR)=N3(I)		PRO
		ÎP=1		-PRO
		I=I+1		PRO
	-61-	-IF(-I-J3)19,70,60		-PRC
·	19	IF(13(1))20,22,31		PRO
ASSMENCE				PR
		IC(IPR-1)=-1		
		GO-TO-21		PR
		MACH=61		PR
		GO TO 100		-PR
		P3(I)=N3(I)	남화회 학생의 본문에는 살인하는 사람이 가운 경우의	PR
gratus interp		-GO TO (31,32,33,34,35,36,37), IP TE(IPR)=P3(I)		*PR
		IP=IP+1		-PR
A	- 20	I=I+1		PR
	· .	IF(I3(I))23,22,24		-PR
		WRITE(IOUT, 25)		PR
and desire and		FORMAT (12HOBAD *3 DATA)		∞PR
	- L	GO TO 8		PR
	_32-	ALPHA (-IPR)=P3(-I-)		-PR
		GO TO 26	공동물에 하시네를 보는데 그렇게 하나요 보이다.	PR
	-33	THERM(IPR)=P3(I)		-PR
		GO TO 26		PR
n postakovanj	34-	RES-I-S-T-(-I-PR-)=P3-(-I-)		~PR
		GO TO 26		PR
	-35	CAP(IPR)=P3(I)		-PR
		GO TO 26		PR
	-36-	UEN(IPR)=P3(I)		-PR
		CAP(IPR)=CAP(IPR)*DEN(IPR)		
operation and		-G() -T() -2-6	AND THE RESIDENCE OF THE PROPERTY OF THE PROPE	-PR
	37	EPSI(IPR)=P3(I)		PR
		-IPR=IPR+1		-PR
		IC(IPR)=0		PR
		GO TO 14	aus aus aus quantique de nome au automorphisme com entre de mandre de la compansión de la c	-PR
		IC(IPR-1)=-1		
pr vlevien d	AD TO THE PARTY OF	ma [a] R = 55 - 1 - 10 - 10 - 10 - 10 - 10 - 10 -		C C
		IH=2		PR
		IM=1 IG=1		-PR PR
		TMIN=TE(1)		PR PR
		DO 42 I=IH, IPR		PR
		IF(IC(I))42,42,45		FI
PASSES 94		$I \cup = I - 1$		PR
		-GO-TO-51		F 19
		CONTINUE		PR
		-IJ=IPR		-PR
		DO 40 I=IH,IJ		PR
p@1004-412		IF (TMINTE(I)) 40,23,41		***************************************
		TMIN=TE(I)		PR
naverben.		IM=I		-PR
		CONTINUE		PF
		-IF (-IM-16)47,50,52		-PR
		MACH=46		PF
no state		namena communicación respectados communicacións consistentes consistentes con la fina de la fina de la fina de		PF
		IG=IG+1		PR
	1-8-3-	IF(IG-IJ)80,81,182		P. Nach prove Ports
		IH=IG+1		PF
		TMIN=TE(IG)		PR
				DO
		IM=IG		PR PR

• 1	GO TO 100	DDCa
4	52 TEMP=TE(16)	PRO3
75.	TE(IG) = TE(IM)	PRO3
	TE(IM)=TEMA	PRO3
	TEMP=ALPHA(IG)	PRO3
المعاددة والمعارض عبر	ALPHA(1G)=ALPHA(1M)	PR03
1	ALPHA(IM)=TEMP	PRO3
_ }	TEMP=THERM(IG)	PRO3
	THERM(IG)=THERM(IM)	PRO3
_11	THERM(IM)=TEMP	PR03
	TEMP=RESIST(IG)	PRO3
NEW CHARLES AND	RESIST(IU)=RESIST(IM)	PRO3
	RESIST(IM)=TEMP	PRO3
	TEMP=CAP(IG)	PRO3
(I)	CAP(IG)=CAP(IM)	PRO3
ì	-CAP(-IM)=CAP(-IG)	-PR03
	TEMP=DEN(IG)	PRO3
un jamesereve	DEN (IG) = DEN (IM)	PRO3
***	DEN(IM)=TEMP	PRO3
	TEMP=EPSI(IG) EPSI(IG)=EPSI(IM)	PRO3
1		PRO3 PRO3
	GO TO 50	PRO3
}	81—IF(-IJ-I-PR)-82-85-84	PR03
d design out the	82 IG=IG+1	
		allegaturanis es est com 1984.
*,	IM=IG	
		-PRO3
	GO TO 83	PRO3
and the second second	84-WACH=8-1	PRO3
<i>₹</i>	GO TO 100	PRO3
<u> </u>	-85 CONTINUE	
C	ALL INFO IN TABLES AND ARRANGED IN INCREASING TEMPERATURE ORDER	PRO3
	NOW PICK OUT TABLE NUMBERS	PRO3
ر ا	DO 87 I=1, IPR	PRO3
Automorphise programme transfer		PRO3
4	88 IM=IC(I)	PR03
-)	-89 IF (IZD (IM)) 90,91,92	-PRO3
	90 MACH=89	PR03
		-PR03
j	91 $IZD(IM)=I$	PRO3
mand is the company of		PRO3
. 3.	92 WRITE(IOUT, 93)	PRO3
- 1	—93 FORMAT (27HODUPLICATE TABLE NUMBER, *3)	רטטט
	GO TO 23	PRO3 PRO3
2×	-87 CONTINUE	
1	MERGE TABLES TO COMPLETED FORM	PRO3 PRO3
ar Jakasannin	I-A=1 DO 95 I=1,6	PRU3
	DO 32 1-190	PRO3
7	IF(IZC(I))96,97,98	PRO3
		PR03
	96 MACH=95 GO TO 100	PRO3
	GO 10 100 	PRO3
ALCOHOLD SO	99 IG=IZD(I)	PRO3
4	1 TAB(I)=IA	PRO3
, C.	104 TES(IA) = TE(IG)	PRO3
	ALPHAS(IA)=ALPHA(IG)	PRO1
- See	MICHARICAN CHAIRM	
	THERMS(IA)=THERM(IG)	PRO3
		PRO3

and the same			
and States		SULNIC (T.L.) = (SEAL(T.C.)	ם האים
, ¥	,		PRO3
manda la provincia de la constanta de la const			PRO3
î_	•		PRO3
			PRO3
			PRO3
SEC. OF ALCOHOL.	**************************************		PRO3
1			PRO3
	1//2		PRO3
teach (All Marianteen	103		PRO3 PRO3
			PRO3
(1) Y			PRO3
E Miles Signature Control of the	100		PRO3
	O-Q		PRO3
			PRO3
			PRO3
ć.			PRO3
Lance	T T L		PRO3
W. W.			PRO3
-			PRO3
1			PRO3
			PRO3
			PRO3
terreta produces de	A C. B. SPECIAL PROPERTY AND THE		PRO3
3			PRO3
and the state of t	1-1-2 -		PRO3
1			PRO3
_			PRO3
4 M			PRO3
strone. A custome	1-1-3-		PRO3
1		IG=IG+1	PRO3
· ·		IF(IC(IG))115,114,107	PRO3
	115	IH=3	PR03
-1-		GO TO 114	PRO3
1	107	IA=IA+1	PRO3
3 constraine of the confe	95		PRO3
		IA=IA-1	PRO3
		-IF (200-IA)117,118,118	PRO3
	117	WRITE(IOUT, 119) IA	
-	119	FORMAT(14,17HTABLE ENTRIES, *3)	to Canacia successioni
	4	GO TO 23	PR03
SPATISHES ASSESSED	118-		PROS
2 %		NP3=1	PRO3
- +	negociante de la companya del la companya de la com	- I M=1	
4.1		NSG=1	
-		-1-X=1	**************************************
11		XXX=ICS(IX)	
tin Jumes	deriense intrigera, desparantement	NN=53+IW	Managarananing
		IF (ABS(XXX-ZA(NN))-1.E-5)1003,1003,1002	
		IF(IX-200)1004,1005,1005	Nedan tandariana
ana Parana		-GO-TO-1006	Padagana o Armon
(* * * * * * * * * * * * * * * * * * *		WRITE(IOUT, 1007)	
and for the	:	FORMAT (21HOTE MATERIAL MISSING)	Darty/SS/PhonePrisitor
. 3	1000	GO TO 8	No.
	-1003	NON-IE-ICS (-I-X)	
	1000	IXB(NONIE)=IX	
- 1		-IF(ICS(IX))1010,2081,2081	
	-	IF(IX-200)1009,1010,1010	Beng lettermeter volce
and the same	an Tappin	- LX-IJX+1	on the same of the same
		GO TO 1008	Manings growth well-older



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SIBFTC PRO4
                LIST, DECK, REF, DD, XR7
      SUBROUTINE PRO4
                                                                                  PRO4
      COMMON Z
                                                                                  PRO4
      DIMENSION Z(20000), CONTRA(200), EMISIA(200), TEA(200), ALPHAA(200),
                                                                                  PRO4
                                                                                  PRO4
     2THERMA(200), RESIA(200), CAPA(200), DENA(200), EMISOA(200), IZA(200),
                                                                                  PRO4
     31CA(200), IZC(30), ITABA(30), IZD(30), I4(1830), P4(1830), N4(1830),
     4TE(200),THERM(200),CAP(200),DEN(200),RESIST(200),ALPHA(200),EMISO
                                                                                  PRO4
     5(200), EMISI(200), CONTR(200), IC(200)
      DIMENSION IXB(20), IXE(20), ZA(200)
      EQUIVALENCE (Z(832), MACH), (Z(11), LERR), (Z(14), CONTRA(1)), (Z(214),
                                                                                  PRO4
     2EMISIA(1)), (Z(414), TEA(1)), (Z(2446), ALPHAA(1)), (Z(2646), THERMA(1))
                                                                                  PRO4
     3, (Z(2846), RESIA(1)), (Z(3046), CAPA(1)), (DENA(1
                                                          ),Z(3246)),(Z(3446
                                                                                  PRO4
     4), EMISOA(1)), (Z(5000), ICA(1)), (Z(8169), ZA(1)), (Z(8139), IZC(1)),
                                                                                  PRO<sub>4</sub>
     5(Z(8109),IZD(1)),(Z(15940),ITABA(1)),(Z(10000),I4(1)),(Z(11830),
                                                                                  PRO4
     6P4(1)),(Z(11830),N4(1)),(Z(8108),I),(Z(8107),N),(Z(8106),TEMP),
                                                                                  PRO4
     7(Z(8105), IPRO), (Z(662), IPR4), (Z(663), NP4), (Z(8104), IP), (Z(8103),
                                                                                  PRO4
     8NTEMP), (Z(830
                     ),J4),(Z(7900),THERM(1)),(Z(7700),CAP(1)),(Z(7500),
                                                                                  PRO4
     9DEN(1)), (Z(7300), RESIST(1)), (Z(7100), ALPHA(1))
                                                                                  PRO4
                                                                                  PRO4
      EQUIVALENCE (Z(6900), EMISO(1)), (Z(6700), EMISI(1)), (Z(6500), CONTR
                                                                                  PRO4
     2(1)),(Z(8102), IH),(Z(8101), IM),(Z(8100), IG),(Z(6499), TMIN),(Z(6299
     3),TE(1)),(Z(6298),IJ),(Z(6297),IA),(Z(5997),IC(1)),(Z(2),IOUT)
                                                                                   PRO4
      EQUIVALENCE (Z(4415), MATC), (Z(4416), MATR), (Z(17416), IXB(1)),
     1(Z(17436), IXE(1)), (Z(627), ZA(1)), (ZA(79), MH), (ZA(119), MC)
      NAMELIST/NAM1/ICA/NAM2/TEA/NAM3/THERMA/NAM4/CAPA/NAM5/DENA/
     INAM6/RESIA/NAM7/CONTRA/NAM8/ALPHAA/NAM9/EMISIA/NAM10/EMISOA
      NAMELIST/NAM11/IXB/NAM12/IXE
                                                                                   PRO4
      LERR=0
                                                                                   PRO4
      IPRO=IPR4
      IPR4=1
                                                                                   PRO4
    1 IF(NP4)2,205,4
    2 MACH=1
                                                                                  PRO4
  100 WRITE (IOUT, 101) MACH
  101 FORMAT (32HOMACHINE ERROR, PRO4, STATEMENT 14)
                                                                                   PRO4
      GO TO 8
                                                                                   PRO4
    4 DO 5 I=1, IPRO
      Z(1+9799)=TEA(I)
                                                                                   PRO4
      Z(I+9599)=ALPHAA(I)
                                                                                   PRO4
      Z(1+9399)=THERMA(1)
                                                                                   PRO4
                                                                                   PRO4
      Z(I+9199)=RESIA(I)
                                                                                   PRO4
      Z(I+8999)=CAPA(I)
                                                                                   PRO4
      Z(I+8799)=DENA(I)
                                                                                   PRO4
      Z(I+8599)=EMISOA(I)
      Z(I+8399) = EMISIA(I)
                                                                                   PRO4
      Z(I+8199)=CONTRA(I)
                                                                                   PRO4
                                                                                   PRO4
    5 IZA(I) = ICA(I)
  205 DO 94 I=1,30
                                                                                   PRO4
       IZC(I) = ITABA(I)
                                                                                   PRO4
       IZD(I)=0
   94 ITABA(I)=0
                                                                                   PRO4
    3I=1
   21 IF(I4(I))6,15,10
                                                                                   PRO4
                                                                                   PRO4
    6 WRITE (IOUT , 7)
    7 FORMAT(20HOILLEGAL CONTROL, *4)
    8 LERR=1
                                                                                   PRO4
    9 RETURN
                                                                                   PRO4
   10 IF(P4(I)-1.)6,11,12
                                                                                   PR<sub>0</sub>4
   12 IF(P4(I)-30.)13,11,6
   13 N=P4(I) +.01
                                                                                   PROA
```

(*)			
1	110	IC (IPR4)=N	ngo sani i consumina ny ana
	15		PRO4 PRO4
- >	17	IF(N4(I)-30)16,16,6	PRO4
-1	16	IC (IPR4)=N4(I) NTEMP=N4(I)	PRO4
]4	IP=1	PR04
-Miston	۷.1		PRO4 PRO4
			PRO4
	20		PRO4_
		IC(IPR4-1)=-1 GO TO 21	PRO4
-(:)-	60		PRO4
7	402	GO TO 100 GO TO (31,32,33,34,35,36,37,38),IP	PRO4 PRO4
(_)	2.1	TE(IPR4)=P4(I)	PRO4
en de	./26	IP=IP+1 I=I+1	PRO4 PRO4
			PRO4
110,3		WRITE(IOUT, 25) FORMAT(12HOBAD *4 DATA)	PRO4
		GO TO 8	PRO4
- J	32	THERM(IPR4)=P4(I)	PRO4 PRO4
77	33	GO TO 26 CAP(IPR4)=P4(I)	PRO4
1		GO TO 26	PRO4
1.7%	34	DEN(IPR4)=P4(I) CAP(IPR4)=CAP(IPR4)*DEN(IPR4)	PRO4
- /	mattendari ne vertere	GO TO 26	PRO4
	35	RESIST(IPR4)=P4(I) GO TO 26	PRO4
		CONTR(IPR4)=ALPHA(IPR4)	PRO4
المذب	400	IPR4=IPR4+1 IC (IPR4)=0	
77		GO TO 14	PRO4
		P4(I)=N4(I) IF(NTEMP-21)402,403,403	PRO4_ PRO4
_ 1_		ALPHA(IPR4)=P4(I)	PRO4
	37	IF(NTEMP-10)403,403,26 EMISO(IPR4)=P4(I)	PRO4 PRO4
		GO TO 26	PRO4
- }	38	EMISI(IPR4)=P4(I) GO TO 400	PRO4
· ·	70	IC(IPR4-1)=-1	magazina (Pari - A a a a a geometria
		IPR4=IPR4-1 IH=2	PRO4
-102			PRO4
- F		IG=1 TMIN=TE(1)	PRO4 PRO4
	83	DO 42 I=IH, IPR4	PRO4_
		IF(IC (I))42,42,45	DDO4
-1	<u> </u>	IJ=I-1 GO TO 51	_PR04
	42	CONTINUE	PRO4
	51	IJ=IPR4 DO 40 I=IH•IJ	PRO4 PRO4
		IF(TMIN-TE(I))40,23,41	manufact to the control of the contr
- }	41	TMIN=TE(I) IM=I	PRO4 PRO4
	40	CONTINUE	PRO4
		and the second of the second o	411

-			entropies of the second
1	116	IF(IM-IG)47,50,52	PRO4
	41	MACH=46	PRO4
		GO TO 100	PRO4
and the second	50	IG=IG+1	PRO4
	183	IF(IG-IJ)80,81,182	
-1		IH=IG+1 .	PRO4
	O W		PRO4
2000004	nik William nikata bira (nikat) niping sabara	TMIN=TE(IG)	
44		IM=IG	PRO4
		GO TO 51	PRO4
	182	MACH=183	
20.400		GO TO 100	PRO4
	E 2		
	24	TEMP=TE(IG)	PRO4
		TE(IG)=TE(IM)	PR04
-ii-a-a-		TE(IM)=TEMP	PRO4
Carrow.		TEMP=THERM(IG)	PRO4
- }		THERM(IG)=THERM(IM)	PRO4
		THERM(IM)=TEMP	PRO4
		TEMP=CAP(IG)	PRO4
, with dis-			
_ (_		CAP(IG)=CAP(IM)	PRO4
l		CAP(IM)=TEMP	PRO4
		TEMP=DEN(IG)	PRO4
,,,,,,,	**************	DEN(IG)=DEN(IM)	PRO4
Ì		DEN(IM)=TEMP	PRO4
	angle and and the second	TEMP=RESIST(IG)	PRO4
		RESIST(IG)=RESIST(IM)	PRO4_
1		RESIST(IM)=TEMP	PRO4
		TEMP=ALPHA(IG)	PRO4
		ALPHA(IG)=ALPHA(IM)	PRO4
1.7		ALPHA(IM)=TEMP	PRO4
		TEMP=EMISO(IG)	PRO4
·		EMISO(IG)=EMISO(IM)	PRO4
			The section is
7		EMISO(IM)=TEMP	PRO4
		TEMP=EMISI(IG)	PRO4
The same		EMISI(IG)=EMISI(IM)	PRO4
		EMISI(IM)=TEMP	PRO4
-7		TEMP=CONTR(IG)	PRO4
1		CONTR(IG)=CONTR(IM)	PRO4
- Parish			description of the communication
		CONTR(IM)=TEMP	PRO4
		GO TO 50	PRO4
	81	IF(IJ-IPR4)82,85,84	PRO4
ه درې	82	- IG=IG+1	
		IH=IG+1	AND THE PERSON NAMED IN COLUMN TWO IS NOT THE OWNER.
1		IM=IG	
-(_)-		TMIN=TE(IM)	PRO4
		GO TO 83	PRO4
			PRO4
	84	MACH=81	
		GO TO 100	PRO4
	85	CONTINUE	
, (C) (S		DO 87 I=1, IPR4	PRO4
- -		IF(IC(I))87,87,88	PRO4
6	ρρ	IM=IC(I)	PRO4
/ 'S		IF(IZD(IM))90,91,92	PRO4
1	90	MACH=89	PRO4
		GO TO 100	PRO4
	91	IZD(IM)=I	PRO4
	- A	GO TO 87	PRO4
	~ ~		PRO4
		WRITE(IOUT, 93)	FRU*
	93	FORMAT (26HODUPLICATE *4 TABLE NUMBER)	
1		GO TO 23	PRO4
- 1	87	CONTINUE	PRO4
10 M		1 A=1 - 112	PRP4
	. ,		

		The state of the state of
DO 95 I=1,30	ta and the state of	PR04
IH=1 IF(IZC(I))96,97,98		PRO4 PRO4
96 MACH=95	taring and the second s	PRO4
GO TO 100		PRO4
97 IF(IZD(I))96,95,99		PRO4
99 IG=IZD(I)		PRO4_
ITABA(I)=IA		PRO4
104 TEA(IA)=TE(IG)	anga dagan yang daga sagan gan yang sagai sa	PRO4
ALPHAA(IA)=ALPHA(IG)		PRO4
RESIA(IA)=RESIST(IG)		PRO4
THERMA(IA)=THERM(IG)		PRO4 PRO4
CAPA(IA)=CAP(IG) DENA(IA)=DEN(IG)		PR04
EMISOA(IA)=EMISO(IG)		PRO4
EMISIA(IA)=EMISI(IG)	and the second second is a substitution of the second second second second second second second second second	PRO4
ICA(IA)=IC(IG)		PRO4
CONTRA(IA)=CONTR(IG)	<u>na mitante para da Arginete de proposación de la media francia de la media de la media de la media de la media</u>	PRO4
GO TO (102,103,107), IH		PRO4
102 IH=2		PRO4
IA=IA+1		PRO4_
IG = IG + 1		PRO4
GO TO 104	and the second	PRO4_ PRO4
103 IA=IA+1 IG=IG+1	*	PRO4
IF(IC(IG))105,104,107	na (n. n. surpussiyasiga pagada abada karan aya surun yapa saya marakana magada da da yanan sar	PRO4
105 1H=3		PRO4
GO TO 104	The state of the s	PRO4
98 IF(IZD(I))96,108,99		PRO4
108 IG=IZC(1)		PRO4
ITABA(I)=IA	··· voimentalistica	PRO4
114 TEA(IA) = Z(IG+9799)		PRO4
ALPHAA(IA)=Z(IG+9599)		PRO4 PRO4
THERMA(IA)=Z(IG+9399) RESIA(IA)=Z(IG+9199)	*	PRO4
DENA(IA)=Z(IG+8799)	and the state of t	PRO4
EMISOA(IA)=Z(IG+8599)		PRO4
EMISIA(IA)=Z(IG+8399)	mandenski sjen militari andre i navenski se se same se	PRO4
CONTRA(IA)=Z(IG+8199)		PRO4
CAPA(IA)=Z(IG+8999)		PRO4
ICA(IA)=IZA(IG)		PR04
GO TO (112,113,107), IH		PRO4
112 IH=2		PRO4
IA=IA+1		PRO4 PRO4
IG=IG+1 GO TO 114		PRO4
□ 113 IA=IA+1	e de la companya de l	PRO4
IG=IG+1	or the second	PRO4
IF(IC(IG))115,114,107		PRO4
115 IH=3		PRO4
GO TO 114	and a suppose the suppose of the sup	PRO4
107 IA=IA+1		PRO4
95 CONTINUE		PRO4 PRO4
IA=IA-1 IE/200-IA\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\		PRO4
IF(200-IA)117,118,118		I INV
117 WRITE(IOUT, 119) IA 119 FORMAT(I4, 17HTABLE ENTRIES, *4)		
GO TO 23	and the second s	PRO4
118 IPR4=IA		PRO4
NP4=1	•	PRO4
第二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十二十		

```
1004 XX=MATC
      XXX = ICA(IX)
      IF (XXX-XX
                      11001,1002,1001
 1001 IF(IX-200)1003,1005,1005
 1003 IX = IX + I
      GO TO 1004
 2005 WRITE(IOUT,1006)
1006 FORMATI 28HO COLLECTOR MATERIAL MISSING)
 1472 LERR=1
      RETURN
 1002 IXB(MATC) = IX
  010 IF(ICA(IX))1008,1007,1007
  007 IF(IX-200)1009,1008,1008
 1009 IX=IX+1
      GO TO 1010
  008 IXE(MATC)=1X
      IX=1
 1014 XX=MATR
      XXX = ICA(IX)
      IF (XXX-XX
                       11011,1012,1011
 1011 IF(IX-200)1013,1015,1015
-1013 IX=IX+1
      GO TO 1014
 1015 WRITE (10UT, 1016)
 1016 FORMAT ( 28HO RADIATOR MATERIAL MISSING )
      LERR=1
      RETURN
 1012 IXB(MATR) = IX
 1020 IF(ICA(IX))1018,1017,1017
 017 IF(IX-200)1019,1018,1018
 1019 IX=IX+1
      GO TO 1020
 1018 IXE(MATR)=IX
      IX=1
 1034 XXX = ICA(IX)
      IF(ABS(XXX-ZA(79))-1.E-5)1032,1032,1031
 1031 IF(IX-200)1033,1035,1035
 1033 IX = IX + I
      GO TO 1034
 1035 WRITE (10UT , 1036)
 1036 FORMATI 27HO HOT SHOE MATERIAL MISSING)
      GO TO 1472
 1032 NONIE=ICA(IX)
      IXB(NONIE) = IX
 1040 IF(ICA(IX))1038,1037,1037
 1037 IF(IX-200)1039,1038,1038
1039 IX=IX+1
      GO TO 1040
 1038 IXE(NONIE)=IX
      IX = 1
 1054 XXX=ICA(IX)
       IF (ABS(XXX-ZA(119))-1.E-5)1052,1052,1051
 1051 IF(IX-200)1053,1055,1055
 1053 IX=IX+1
       GO TO 1054
 1055 WRITE ( 10UT , 1056)
 1056 FORMAT (28HO COLD SHOE MATERIAL MISSING)
       GO TO 1472
 1052 NONIE=ICA(IX)
       IXB(NONIE)=IX
 1060 IF(ICA(IX))1058,1057,1057
```

		· · · · · · · · · · · · · · · · · · ·		and the state of t		- Committee and the State of the Committee of the Committ	in the second	alanananya angaran alananya angarangan angarangan angarangan angarangan angarangan angarangan angarangan angar	
1057	IF(IX-	200)1059•1	1058 • 1058						
059	IX=IX+		n - Tanak Aryung, umum an ang menuntuk perang menungkan pengungan bendan Arabapan mela			* p	<u>, in the second description of the second property of the second description of the second second description of the second second description of the second secon</u>		-
1058	IXE (NO!	VIE)=IX				ing the property of the state o			
303	RETURN	<u>JE</u>						PR04	
dices.	END			<u></u>					
- []							ndangsylvanya nyawatense wang pendatan dana benjabuhan yaktum yaktumpan	No.	
<i>(1)</i>									
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- 1		- <u> </u>							
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-- SIBFTC-PRO5 -- LIST, DECK, DD, XR7---
       SUBROUTINE PRO5
                                                                                    P
                                                                                   P
       COMMON Z
                                                                                    Р
       -DIMENSION-Z(1600<del>0) yI5(730) yN5(730) yP5(730) yFIME(100) yISUR(10)</del>
      2T(100),F1C(100),F1R(100),F2C(100),F2R(100),DELTA(100),TSUR(10)
       DIMENSION-IXB(20), IXE(20)
                                                                                    P
       EQUIVALENCE (Z(3656),TIME(1)),(Z(8459),ISUR(1)),(Z(3756),T(1)),
                                                                                    P
      3),(Z(4256),DELTA(1)),(Z(6991),N5(1)),(Z(6991),P5(1)),(Z(7721),
                                                                                    P
                                                                                    ρ
      415(1-))。(Z(2)。IOUT)。(Z(11)。LERR)。(Z(84<del>51)。I</del>)。(Z(8452)。N)。(Z(8453)。
                                                                                    P
      5NA),(Z(8454),TEMP),(Z(4356),OLDSOL),(Z(4357),ALBEDO),(Z(4358),
      6STEFAN),(<del>2(8455),TMIN),(2(8456),J),(2(4</del>359),1TIME),(2(8458),K),
      7(Z(831),J5),(Z(4360),TSUR(1))
       EQUIVALENCE-(2(17416),1XB(1)),rZ(17436),TXE(1));
       NAMELIST /NAM1/OLDSOL/NAM2/ALBEDO/NAM3/STEFAN/NAM4/TIME/NAM5/ISUR
      1/NAM6/T/NAM<del>7/F1C/NAM8/F1R/NAM9/F2C/NAM10/F2R/NAM11/DELTA</del>
        I = 1
       LERR=0-
        IF(I5(I))1,3,4
     1-WRITE (IOUT, 2)
     2 FORMAT(19HOILLEGAL *5 CONTROL)
    22 LERR=1- --
    15 RETURN
    -5- I=I+1---
       GO TO (11,12,13,34,34,34,34,34,34,34,34,21),N
     3-N=N5-(-I-)-
       GO TO 5
     4-NA=P5(I)-
        TEMP=NA
      IF (ABS (TEMP-P5(I))-1.E-7)6,6,1
     6 N=NA
       -GO-TO5----
    11 IF(I5(1))7,8,9
     -7-WRITE(10UT,10)
    10 FORMAT(19HOYOU GOOFED *5 DATA)
     -- GO TO 22--
     8 OLDSOL=N5(I)
    17 IF (J5 I) 26,28,16
     9 OLDSOL=P5(I)
      ---GO--TO--1-7---
    16 I=I+1
       -IF(I5(I)-)-17-<del>,3,</del>4-
    12 IF(I5(I))7,18,19
    18-ALBEDO=N5-(1-)-
       GO TO 17
    19-ALBEDO=P5-(-I-)-
       GO TO 17
    13-If(I5(I))7,20,23
    20 STEFAN=N5(I)
     versesse.G0resuTe0esenJe7essissiseeriseeemens
    23 STEFAN=P5(I)
       -GO-TO-1-7---
    21 CALL HEAT (TIME, T, FIC, FIR, F2C, F2R, DELTA)
       TMIN=TIME(-1)
        DO 24 J=2,100
       __I_E_(_TM_I_W=T_I_ME(_J__)_24,7,25
    25 IF(TIME(J))7,26,7
```

personal services	- against	and the second s
	. 26	- ITIME=J-1 -
Annual Control of the		GO TO 27
	24	CONTINUE ITIME=100
	27	DO 29 J=2,10
and the same and the same		TSUR(J)=ITIME
		GO TO 17
	34	J=N=3
1 400		ISUR(J)=1
	45	K=ISUR(J)+100*(J-1)
		IF(I5(I))41,42,43
	41	IF(N-4)17,401,17
-(1)	401	-IXB(17)=1
		IXE(17) = ISUR(J)
		GO TO 17
		TIME(K)=N5(I)
pri Jesus Superparation de		GO-TO-44
		TIME(K)=P5(I) I=I+1
\overline{a}	44	ISUR(J)=ISUR(J)+1
		GO TO 45
		DO 50 I=1,7
and Thermodynamics		
		WRITE(IOUT,52)
	52	FORMAT (27HOPROGRAM NEEDS MORE *5 DATA)
2,224	50	GO TO 22 CONTINUE
	J	IF(ISUR(1)-2)54,51,54
je namana anterproportitelinio		
		IF(ISUR(I)-1)51,58,56
-		IF(-I-SUR(I-)-I-SUR(1-)-)59+58+59
		WRITE(IOUT, 60)
		FORMAT(21HOINCONSISTENT *5 DATA) GO TO 22
	5.8.	
		RETURN
		END
San		
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SIBFIC PRO6 LIST, DECK, REF, DD, XR7
      SUBROUTINE PRO6
      COMMON Z
      DIMENSION Z(20000), 16(200), P6(200), N6(200)
      -EQUIVALENCE-(Z-(9051)-, I6(1)) , (Z(8451) , N6(1) ) , (Z(8451) , P6(1)) ,
     1(Z(832),J6),(Z(4400),RE),(Z(4401),SEGM),(Z(4402),TIMAX),
     <del>2+Z+4403-}+TMIN}++Z+4404}+TMX}++Z+4405}+TIMF}++Z+4406}</del>
     3,TIMPL),(Z(4407),TIMPS),(Z(4408),XINPUT),(Z(4409),TMAP),
     ~~(~~~10^)-,-I&&-)-,-(~~411-)-,-EPST-)-,-(~4412-)-,NL-)-,-(~~4413-)-,NS)-,-
     5(Z(4414),TMACH),(Z(4415),MATC),(Z(4416),MATR),(Z(4417),
     6NRSTRT);(Z(4418);TINIT);(Z(11);LERR);(Z(5200);LB);(Z(2);IOUT);
     7(Z(4419), CFACT)
      T = 1
      LERR=0
   20 IF(I=J6)105,105,121
   23 WRITE(IOUT, 22)
   22 FORMAT(11HOPRO6 ERROR)
      LERR=1
      RETURN
  105 IF(I6(I))23,130,131
  130 NP=N6(I)
      GO TO 132
  131 NP=P6(T)+1.E-5
  132 I = I + 1
     -GO TO-(1,2,<del>3,4,5,6,7,8,9,10,11,12,13,14,75,16,17,18,19,120,121)</del>NP
    1 IF(I6(I))23,30,31
   -30-RE=N6(I)-
      GO TO 24
   -3-1--RE=P6(-I-)-
   24 I = I + 1
     ---GO-TO-20-
    2 IF(I6(I))23,32,33
   32-SEGN=N6(I)
      GO TO 24
   33-SEGM=-P6(-I)-
      GO TO 24
    3-IF(I6(I))23,34,35
   34 TIMAX= N6(I)
      GO-FO-24
   35 TIMAX=P6(1)
    ----G0-T0-24----
    4 IF(I6(I))23,36,37
   36 TMIN= N6(1)--
      GO TO 24
   37-TMIN = P6(-I-)-
      GO TO 24
    5 IF (I6(I))23,38,39
   38 \text{ TMX} = N6(1)
      GO TO 24
   39 TMX=P6(I)
      -GO-TO-24-
    6 IF(I6(I))23,40,41
   40-TIMF-=N6(I-)-
      GO TO 24
   41-TIMF-=P6(I)
      GO TO 24
    7-IF(I6(I))23,42,43
   42 CFACT = N6(I)
```

```
GO TO 24
-43 CFACT = P6(I)
    GO TO 24
 8 IF (16(1))23,44,45
44 \text{ TIMPL} = N6(I)
  --GU-TU-24---
45 TIMPL=P6(I)
  --GO-TO-24
 9 IF(I6(I))23,46,47
 46 TIMPS = N6(I)
    GO TO 24
 GO TO 24
10 IF (I6(I)) 23,48,49
48 XINPUT = N6(I)
  ---GO TO-24--
49 XINPUT =P6(I)
   -GO-TO-24-
11 IF(I6(I))23,50,51
50 - TMAP = N6(I)
    GO TO 24
51 \text{ TMAP} = P6(I)
    GO TO 24
12 IF (I6(I))23,52,53
 52 ISS=N6(I)
   GO TO 91
 53 ISS=P6(I) +•01
91-IF(ISS-1)92,24,92
92 NP=NP+4
   -1=1+1---
    GO TO 20
13 IF (I6(I))23,54,55
 54 EPST = N6(I)
 ---GO TO 24
 55 \text{ EPST} = P6(I)
 GO TO 24
 14 IF(I6(I))23,56,57
56 NL = N6(I)
    GO TO 24
57 NL = P6(I) +.01
    GO TO 24
-15-IF(-I6(-I-)-23,58,59-
 58 NS= N6(I)
  ---GO TO-24-
 59 \text{ NS} = P6(I) + .01
   -GO TO-24----
 16 IF(I6(I))23,60,61
 60 TMACH = N6(I)
    GO TO 24
 61 TMACH = P6(I)
    GO TO 24
 17 IF (16(1))23,62,63
 62 \text{ MATC} = N6(I)
    ~G ()~~T ()~~2.4~~~~~~~
 63 \text{ MATC} = P6(I) + .01
   -60-T0-24-
 18 IF(I6(I))23,64,65
 64 - MATR = N6(-I-)
    GO TO 24
 65 MATR = P6 (I) + 01
    GO TO 24
```

19	IF(I6(I))23,66,67		
66	NRSTRT =N6(1) GO TO 94	and an experience of the control of	an makan mengangan kelabah sebagai dan mengan berangan dan mengan berangan dan mengan berangan dan mengan beran Pengan berangan bera
94	NRSTRT = Po(I) +.01 IF(NRSTRT-1)24,95,24		
	I = I + 1		opelanticonemo, p. 1000 openimento con provincia encuentriale (comunication principale).
120	GO TO 20 IF(16(1))23,68,69		
	TINIT = N6(1) GO TO 24		
racements contraction as in a contraction of the co	GO/TO 24		
121	-RETURN .		erane og engigen og principalska kalled gild til være i vigert skek i meg skallederindering forstellt forstell
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			Commission of the Principle of the State of

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SIBFTC HEAT LIST, DECK, DD, XR7
      SUBROUTINE HEAT (XA, XB, XC, XD, XE, XF, XG)
      COMMON Z
      DIMENSION Z(16000)
      EQUIVALENCE (Z(2), 10UT)
      DIMENSION XA(100), XB(100), XC(100), XD(100), XE(100), XF(100), XG(100)
      XA=XB+XC+XD+XE+XF+XG
      WRITE(IOUT,1)
    1-FORMAT (33HOSUBROUTINE HEAT IS NOT AVAILABLE)
       CALL EXIT
      RETURN-
       END
SIBFTC UNPAK LIST, DECK, DD, XR7
      SUBROUTINE UNPAK
      COMMON-Z-
      DIMENSION Z(16000), KC(8), I3(1600), K3(220), K4(250), I4(1830), KS(250)
     2, JS(10)
       EQUIVALENCE (Z(5379), I3(1)), (Z(829), J3), (Z(6979), IX), (Z(6980), KA),
     2(Z(6981),KB),(Z(69<del>82),KC(1)),(Z(6990),KD),(Z(10250),K3(1)),(Z(830)</del>
     3,J4), (Z(10000),K4(1)),(Z(10000),I4(1)),(Z(7979),KS(1)),(Z(827),
     435(1)
       IF(JS(3))313,313,1
    1-Kb=J3/8-
      DO 310 KA=1,KB
       KD=K3(KA)
      CALL-SPREAD(KC/1), KD
       DO 311 I=1,8
      -IX = IX + 1
  311 I3(IX) = KC(I) - 1
  310-CONTINUE
       KA = KB + 1
  314-IF(IX-J3)312,313,313
  312 IX = IX + 1
      -I3(IX)=K3(KA)-
       KA = KA + 1
      GO-TO-314
  313 IF(JS(4))413,413,2
    2-KB=J4/8+8-
       IF(KB-250) 14, 14,315
  315 KB=250
   14 DO 316 I=1,KB
  316-KS(I)=K4(I)-
       KB=J4/8
      -1 - X = 0
      DO 410 KA=1,KB
      KD=KS(KA)
       CALL SPREAD(KC(1),KD)
      -DO-411-I-1-8---
       IX = IX + 1
  44)- ] - 1 44 (- [ X -) = K (- (- [ - ) - ] - - 1
  410 CONTINUE
      - KA=KB+1-
  414 IF(IX-J4)412,413,413
  412-IX=IX+I-
       I4(IX)=KS(KA)
       .К.<del>Д., К</del>.Д.+.].....
       GO TO 414
```

```
413 RETURN
      END
                LIST, DECK, DD, XR7
SIBFTC PACK
      SUBROUTINE PACK
      COMMON Z
      DIMENSION-Z(16000);KC(8);K4(250);T4(1830);I3(1600);K3(220);US(10)
      EQUIVALENCE (Z(5379), I3(1)),
                                                   (7(829), J3), (2(830), J4), (
     <del>22</del>(6979),IX),(2(6980),KA),(2(6981),KB),(2(6982),KC(1)),(2(6990),KD)
     3,(Z(10000),K4(1)),(Z(10250),K3(1)),(Z(10000),I4(1)),(Z(827),JS(1))
      IF(JS(4))303,303,1
    1 KB=J4/8
      DO 300 KA=1,KB
      DO 301 I=1.8
       IX = IX + 1
  301-KC(I)=I4(IX)+1
       CALL SQUASH(KC(1),KD)
  300-K4(KA)=KD
       KA=KB+1
  304 IF(IX-J4)302,303,303
  301 IX=IX+1
      K4(KA)=I4(IX)
       KA=KA+1
      GO TO 304
  303 If(JS(3))308,308,2/
    2-KB=J3/8
       IX=0
      DO 305-KA=1-KB-
       DO 306 I=1,8
      -I \times = I \times +1
  306 \text{ KC(I)} = \text{I3(IX)} + 1
       CALL SQUASH(KC(-1),KD)
  305 K3(KA)=KD
      -KA=KB+1--
  309 IF(IX-J3)307,308,308
  307-1X=1X+1---
       K3(KA) = 13(IX)
       KA=KA+1--
       GO TO 309
  308-RETURN-
       END
SIBMAP CHECK
                -M94-999
        ENTRY
                 CHECK
CHECK CLA*-
                 3 -4-
        TMI
                 CHK<sub>2</sub>
       TZE -
                 CHK1
        CLA
                 =1
\mathsf{CHK}1
       -STO*
                 4-9-4
        TRA
                 1,4
                 = 1---
        CLS-
CHK 2
        STO*
                 494
       TRA
        END
$IBMAP-SQUASH-M94,999
        ENTRY
                 SQUASH
        ENTRY
                 SPREAD
                 SQU2,4
SQUASH SXA
                 3,4-
        CLA-
        ADD
                 = 8
                 SQU1
        STA
        PXA
                 0.0
```

	AXT	8,4	
	ALS		
SQU1	ORA TIX	** • 4 *-2 • 4 • 1	on symmetric and annual School property (see fact or special annual see
SQU2	AXT	**,4	
an Galas (maga gapatahagi kan mengasahkan sepata di tetah di telah menen si memerikan me	STO************************************	- 1 • 4	general production and the contraction of
SPREAD	SXA	UNSQ2,4	en en signification of the second of the second
	CLA ADD	3 9 4	ng pepanan ng mikanage u ng upununawa n
	STA	UNSQ1	
	LDQ*	unau Lite of the second and a s	ttafamaistean teoria taluna entitara esta
	AXT	8- ₅ -4	reprofessor na igili i na vinasili kilanga kananda uga pasa 1995 (1997 ka di
	PXA		
	LGL STO	2 ** • 4	Assembly to management (4, 24, 28 before an earlier
and testes from the angles of the second	-T-I-X	mark and greater a produce a superior and the superior an	of and an extension of the second
UNSQ2	AXT TRA	1,4	and the same of
	END		
1			
macamatrica insuración de la minor campación de actividade en concension de la composição de la composição de c	nation and a process in the order sold, while policy in the order of the first sold in the order of the ord		
and the second s	annara eraki i pokulajik kanga ako en nakilaliya erakila		·
estational des la company des la company des la company de la company de la company de la company de la company	tokkourupointaka aparingsapiinkindanapiineke ja sanciitanjasingsapi	AND THE PROPERTY OF THE PROPER	. er seemen inskeppel ins jeden bro
	engan ran i en engango en		y, and the side and the side of the side o
	·《阿斯·尔·斯斯特》(18 1929年)(19 19 19 19 19 19 19 19 19 19 19 19 19 1	**************************************	· · · · · · · · · · · · · · · · · · ·
	and the state of t		standing and the standing standing of the stan
aastaa ta kolontain nepriisida ka tokkin taksi oli maan onen ina biini A ilmun maan	angeren av der Stelle angere en anna et est de de de		COMMENT OF AN ARCHITECTURE STATE OF THE STAT
			·
ernandijas tinas sestimani ir irati sestimas, at ti amanaminini, aanami			rund to representation of the freedom to the second section of the section
			and the second s
ang appropriate and a state of the state of			and the state of t
	COLORED TO THE PROPERTY OF THE		Nadar Sentar oli olympide etilesen etilese
e anti-Paratura (un représentativa de l'apparatura de l'apparatura de l'apparatura de l'apparatura de l'appara			
et at 1 Parties de contrata de la c		And a suppose of the	nya wanagasa ananya yayang wanawahanceanakai k
d and in the contract of the c			ا مناطقه المناطقية المناطقية المناطقية المناطقية المناطقية المناطقية المناطقية المناطقية المناطقية المناطقة ال المناطقة المناطقة ال
			ng kantagan ditang 1900g adam kantagan dian Ing kantagan diang kan
			na kanagani antera yang saminiman malain almah samininte dalam samininte samini dalam kanagan dari samining saminin antera saminin

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SIBFTC MESH
              LIST, DECK, REF, DD, XR7
     - SUBROUTINE MESH----
      COMMON Z
     --DIMENSION-Zi(20000)->PL(8)->L(8)->PHI(8)->DELTH(8)->DELTHE(100)->CORA(8)->
     2CORR(8), LLA(4), THETAX(100), ANGLE(100), KC(100), RIL(100), ROL(100),
     EQUIVALENCE: (Z(5428), TEMPB), (Z(5500), L(1)), (Z(5470), PHI(1)), (Z(546
     -2-2-) • DELTH (-1-)-) • <del>(-2-(-1-1-9-1-6-) • DEL</del>THE (-1-)-) • • (-5-<del>7-0-0-) • CORA (-1-)-) • (-2-(-5-7-08-) • • CORR (-</del>
     31)),(Z(5458),LLA(1)),(Z(5716),THETAX(1)),(Z(5816),ANGLE(1)),(Z(
     412016)-,KC(-1)--,<del>(Z(5916)-,R</del>FL(1)-,(Z(6016)-,ROL(1)-)-,(Z(11816)-,RT(1)-)-,
     5(Z(11716),RO(1)),(Z(5454),TEMPA),(Z(627),ZA(1)),(ZA(158),PL(1)),
     7(Z(5422), TEMP),
                                    (Z(5427), LA), (Z(5450), NCOUNT),
     8 (ZA(-1 ) • X ) • (ZA(-2 ) • Y ) • (ZA(-4 ) • UO) • (ZA(-5 ) • VO) • (ZA(-6 ) • U) • (ZA(-7 ) • V) •
     9(Z(2),IOUT),(Z(11),LERR),(Z(5419),LC),(Z(5418),LD),(Z(5417),PLARGE
      EQUIVALENCE (Z(5416), SUM), (Z(5415), J), (Z(5414), I), (Z(5413), LINE),
     3TEMGA), (Z(5207), RMIN), (Z(5201), R), (Z(5406), THETM), (Z(5202), THETAV)
     4。(Z(5203),DELR),(Z(5405)。KA)。(Z(5404)。KB),(Z(5403),TEMPH)。(Z(5402
     5), TEMPJ), (Z(5401), TEMPK), (Z(5400), N),
     7(Z(5200),LB,<del>L22),(Z(5213),L2),(Z(5214),ITOT,IX</del>),
     8(ZA(166),XIMX),(Z(5208),IMAXP),(ZA(12),XLENGT),(Z(5211),DELX)
     9 - (Z (-5221) - IMAX)
      NAMELIST/NAM1/UO, VO, U, V, X, Y, XIMX, XLENGT, PL/NAM2/PHI, DELTH,
     -1DELTHE,PL,L/NAM3/PLARGE,LB,DELTHE,NGOUNT/NAM4/CORA,GORR,ELA/
     2 NAM5/R, RMIN, THETAV, DELR/NAM6/RIL, ROL, THETAX
     -- LERR=0 ---
      DO 1 I=1,8
      -L-( I-) = PL (-I-) -+ 0-1-
    1 CONTINUE
COMPUTE ANGLES ---
                                                                          ----MESI
      TEMPA = (UO+U)*(UO+U)
                                                                            MES
      TEMPB = (VO+V)*(VO+V)-
                                                                          --- ME'S
      TEMPC=(2.*X-UO-U)**2
                                                                            MES
      TEMPD= (~2~ + + Your V Orac V ) with the 2 commence
                                                        rogen kom vantu. Saujum musumanangen iga ikusanangan pamenanteri dan kuME'S.
      PHI(1)=(4.*X*X-TEMPA-2.*TEMPB-TEMPC)/(-2.*SQRT((TEMPA+TEMPB)*(TEMP
     2C+TEMPB))) -
      IF(ABS(PHI(1)-1.E-3))601,602,602
  601 PHI(1)=1.57079
      GO TO 603
  602-PHI(1)-ATAN(SQRT(1.-PHI(1)*PHI(1))/PHI(1))
  603 IF(PHI(1))200,201,201
  -200-PHI(1)=3.14159+PHI(-1)-
  201 CONTINUE
     --PHI-(2)=(4**Y*Y<del>-2**TEMPC-TEMPB-TEMPD)/(-2**SQRT(-(TEMPC+</del>TEMPB)*(TEMP
     2D+TEMPC)))
      -IF-(ABS-(PH-I-(-2)-1-E-3)-)605-,606-,606-
  605 PHI(2)=1.57079
      -GO-TO-607-
  606 PHI(2)=ATAN(SQRT(1.-PHI(2)*PHI(2))/PHI(2))
                                                                            MES
  607-IF (PHI (2))202,203,203-
  202 PHI(2)=3.14159+PHI(2)
  203_CONTINUE
      PHI(3)=(4.*X*X-2.*TEMPD-TEMPC-TEMPA)/(-2.*SQRT((TEMPD+TEMPC)*(TEMP
     2A+TEMPU))
      IF(ABS(PHI(3)-1.E-3))609,610,610
  609 PHI (3)=1.57079
  610 PHI(3)=ATAN(SQRT(1-PHI(3)*PHI(3))/PHI(3))
  611 IF(PHI(3))204,205,205
```

```
204 PHI(3)=3.14159+PHI(3)
 205-CONTINUE-
      PHI(4)=6.283184-PHI(1)-PHI(2)-PHI(3)
                                                                          MESH
     TEMPE=(U-UO)/(V-VO)
                                                                         ME-SH
      TEMPG=1./TEMPE
                                                                          MESH
      PHI(5)=2.*ATAN(TEMPE)-
                                                                         ME SH
      PHI(6)=2.*ATAN(TEMPG)
                                                                          MESH
                                                                         MESH
      PH-I-(-7-)=PH-I-(-5-)---
      PHI(8) = PHI(6)
                                                                          MESH
                                                                         MESH
COMPUTE DELTA THETA
                                                                          MESH
      DO 2 I=1,8
   -2-DELTH(I)=PHI(I))/PLU(I)/MEDICAL MEST
COMPARE DELTA THETAS AND RE-SET POINTS AND DELTA THETAS AS NECESSARY
                                                                          MESH
    MESH
                                                                          MESH
      IF(DELTH(I)-DELTH(I+4))3,3,4
   4-PL(-I-)=PL(-I-)*DELTH(-I-)*DELTH(-I-+4-)-
                                                                         MESH
                                                                          MESH
      L(I) \approx PL(I) + \cdot 01
   area asser Pull or from Jump to me from Jacob presence assertance assertance
                                                                         MESH
    6 DELTH(I)=PHI(I)/PL(I)
                                                                          MESH
    3 CONTINUE
                                                                          MEST
                                                                          MESH
CALCULATE WORKING DELTA THETAS
                                                                         -ME'SH
    - LB=0-----
                                                                          MESE
      DO 7 J=1,4
                                                                         MESH
      -LA=L6+1---
                                                                          MESE
      LB=L(J)+LB
                                                                          MEST
     -DO-8 I=LA, LB
    8 DELTHE(I)=DELTH(J)
                                                                          MESH
                                                                          -MEST
    7—CONTINUE ———
                                                                          MESH
      IF(LB-100)9,9,10
                                                                         -MESH
   10-WRITE (IOUT-9-1-1)
   11 FORMAT (32HONUMBER OF POINTS TABLE EXCEEDED)
                                                                          MEST
                                                                          -ME-St
     -LERR=1----
                                                                          MEST
      RETURN
                                                                         -MEST
   -<del>9</del>-NCOUNT=0----
                                                                          MEST
   31 LC=1
     -PLARGE-0.
                                                                         and the contract warm
                                                                          MEST
      LD=0
      THETAX (1) = DELTHE (-1) -----
      DELTHE(1)=(DELTHE(2)+DELTHE(LB))/4. +DELTHE(1)/2.
                                                                          ME-SI
      SUM=DELTHE (1)
                                                                          MESI
      J=1
                                                                         MESI
   MESI
      LC=L(J)+LD
                                                                          MESI
      DO-13 I=LA,LC---
      THETAX(I)=DELTHE(I)
      DELTHE(I)=(DELTHE(I+1)+DELTHE(I-1))/4. +DELTHE(I)/2.
                                                                          MESI
   13 SUM=SUM+DELTHE(I)
                                                                          MESI
     -IF(J-3)21,21,20
                                                                          MESI
   21 TEMP=PHI(J)/SUM
      -LA=LD+1 ----
                                                                          -MESI
      DO 16 I=LA,LC
                                                                          MESI
      DELTHE (I) = TEMP * DELTHE (I)
      IF(PLARGE-ABS(THETAX(I)-DELTHE(I)))14,16,16
   16 CONTINUE
     IF(J-3)17,19,24
                                                                          MESI
   17 LD=LC
                                                                          MESI
                                                                          ME-S
   30 J=J+1-
      SUM=0.
                                                                         MES
     GO-TO-18-
                                                                          MESI
   19 LD=LC-1
```

The second secon	GO TO 30 20 LC=LC+1 TEMP=DELTHE(LC) DELTHE(LC)=(DELTHE(L)+DELTHE(LC-L))/4. IF(PLARGE-ABS(TEMP-DELTHE(LC)))22,23,23 22 PLARGE=ABS(TEMP-DELTHE(LC))	DEFETTALENCES	MESH MESH MESH
And the second state of th	20 LC=LC+1 TEMP=DELTHE(LC) DELTHE(LC)=(DELTHE(L)+DELTHE(LC-1))/4. IF(PLARGE-ABS(TEMP-DELTHE(LC)))22,23,23 22 PLARGE=ABS(TEMP-DELTHE(LC))	DELTHE(-LC)-/2	MESH
SSOA	TEMP=DELTHE(LC) DELTHE(LC)=(DELTHE(L)+DELTHE(LC-1))/4. IF(PLARGE-ABS(TEMP-DELTHE(LC)))22,23,23 22-PLARGE=ABS(TEMP-DELTHE(LC))	DELTHE(-LC)-/2	
Signature and the section of	DELTHE(LC)=(DELTHE(1)+DELTHE(LC-1))/4. IF(PLARGE-ABS(TEMP-DELTHE(LC)))22,23,23 22-PLARGE-ABS(TEMP-DELTHE(LC))	DELTHE(LC)/2	111201
and the second state and the s	IF (PLARGE-ABS (TEMP-DELTHE (LC)))22,23,23 22-PLARGE-ABS (TEMP-DELTHE (LC))		Managaran (1994)
and the second s	22-PLARGE-ABS-(TEMP-DEL-FHE-(L-Co)-)		MESH
2770		omprise militar constanti e a constantinamente e constantina e constantina de constantina e constantina e constanti	MESH
enta .	23 SUM=SUM+DELTHE(LC)		MESH
eficia.	LD=LD+1	a annual para para transport from the format and proposed and the Co. Co. State of the format and the format an	MESH
elita.	GO TO 21		MESH
	24 IF (PLARGE-1.E-3)25,25,26	namental and the second control of the secon	Referenciation and in a province of the electric state of the elec
	26 IF(NCOUNT-250)27,27,25		MESH
m b-construction of special construction and	MARINE 247-MCGUN-T-2NGGUN-T-4-1	enderstammen programmen programmen og som formalle state og som formalle formalle formalle formalle formalle for the formal form	MESH
	GO TO 31		MESH
) 	25 CONTINUE	THE PROPERTY OF THE PROPERTY O	MESH
	CALCULATE ANGLE OF LOWER LEFT T/E CORNER		MESH
3	TEMP=(U0+U)/2.		MESH
	TEMPA=(VO+V)/2.		MESH
Andrew Comment Company of the Control of the	CALCOLA ATE COPALED LOCATIONS		MESH
essa.	CALCULATE CORNER LOCATIONS		MESH
1			
J	CORA(2)=PHI(1)		managana mingga tangga sa mingga sa ming
Andreas and a second	CORA(3)=PHI(1)+PHI(2)		
	CORA(4)=PHI(3)+CORA(3)	Bakastan kanapatan kanapatan pengangan kanapatan pengangan pengangan pengangan pengangan pengangan pengangan p	identification AAET C 1
	1F(THETAE)41;42;42 41 CORA(5)= THETAE+PHI(5)		MESH MESH
/_	CORA(6) = CORA(5) + PHI(6)	and an experience of the second of the secon	MESI
7	CORA(6)=CORA(5)+PHI(5)	·	MESI
	CORA(8)=6.283184+THETAE	wood name of the company of the comp	MESI
, w	GO TO 43		MESH
- Secretariore market accommission of	CORA-(-5-)THE-TAE	The Control of the Co	MESH
	CORA(6)=THETAE+PHI(5)		MESH
,,,! 	CORA(7)=CORA(6)+PHI(6)	Management of the company of the com	MESH
2)	CORA(8) = CORA(7) + PHI(5)		MESH
	43 CONTINUE	рация и поменую и перенция и поменя в поменя в поменя в предоставления подражения в предоставления в пре	MESI
<i>)</i>	COMPUTE CORNER RADII		MESI
manuscrator (apages 1981) ones	CORR(1)=SQRT(TEMP*TEMP+TEMPA*TEMPA)	TO SEPREMENTS	MESI
	CORR(2) = SQRT((X-TEMP)**2+TEMPA**2)		MESI
J		mengan an mananan mengandi berangan an	MESI
	CORR(4) = SQRT(TEMP**2+(Y-TEMPA)**2)		MESI
1	CORR (5) = SQRT (-(-(U-U0-)**2+(V-V0-)**2)/4.)	emperature of the second of th	
	CORR(6) = CORR(5)		MESI
A STATE OF THE PARTY OF THE PAR	CORR(174)=CORR(454)=CORR(4	DOLUMENTO CONTROL SERVICE SALVANE AND	
3	CORR(8)=CORR(5)		MESI
	CALCULATE SIDE NUMBERS		- MESI
المدن	LLA(1)=L(1)		MESI
 	LLA-(2)=L(2)+LLA-(1-)		MES
	LLA(3)=L(3)+LLA(2)		MES
Secure Shipping and Control	CALCULATE AND	нове, шиво вы странтировностирования раб навости, не доминательностировности по выполнения от выполнения от доминательности от домина	MES
	CALCULATE MINIMUM RADIUS		MES MES
	TEMG=(U-UO)/2. TEMGA=(V-VO)/2.		MES
	IF (TEMGATEMGA) 32,32,33		ME
	32 RMIN=TEMG		MES
	32 RITIN-ILITO	and a single control of the second of the se	
	33 RMIN=TEMGA		MES
	34 R=RMIN	a processor of the communication of the communicati	MES
1	COMPUTE AVERAGE THETAS		MES
	SUM= Q-	entergian entre sons avoid report sign. (1) In the consumer and an adjustment of the consumer and adjustment of the consumer	MES
A.	DO 35 I=1,LC		MES
Andread and the second second second	36 SUMESUM + DELIHE (LI)	A CONTRACTOR OF THE CONTRACTOR CO	MES
	35 CONTINUE		MES

)	TEMPB=LC	ME
S	THE TAVESUM/TEMPO	ME
% .	CHOOSE DELTA R	ME
	38 DELR=R*THETAV	Proposition of the same of the same
)	CALCULATE INCREMENT NUMBER	ME
مهاجه بالمتالية الدواجية		ME
	C SET UP SUBROUTINE	ME
]	CALL POINT (UO, U, TEMPC, TEMPD, O.)	ME
	CALL POINT (VO, V, TEMPC, TEMPD, -1.)	ME
)	CALCULATE RADIT AT BACK SIDE OF INCREMENTS ALONG THE EDGE (RL) AND	
	C ALONG PLATE EDGE (RL) ALSO COMPUTE THETA AT THE SAME POINTS	in a company to the control of the Co
Zicheling der Leit	TEMPCEATAN (TEMPA)	ME ME
h	TEMPD=COS(TEMPC) TEMPE=SIN(TEMPC)	ME ME
	THETAX(1)=0.	ME
)	N=1	ME
	TEMPG=VO	ME
		PIL ME
Section Company	TEMPJ=0.	ME
		мс МЕ
	TEMPK = X	
	LA=LLA(1) 	. ME ME
	49 DO 45 K=LB; LA	ME
adjubilitaredis. 9 at	TEMPIZ=(SIA(THETAX(K)))*TEMPO+GOS(THETAX(K))*TEMPE)	M
	RIL(K)=(TEMPG-TEMPA)/TEMPI	ME
	ROL(K)=(TEMPJ-TEMPA)/TEMPI	ME
)	45 THETAX(K+1)=THETAX(K)+ DELTHE(K)	ME
	N=N+1	ME
	LB=LA+1	ME
paris attendente Fe		on accommended ME
	DO 46 K=LB,LA	ME
<u></u>	TEMPI = - COS(THETAX(K))*TEMPD+SIN(THETAX(K))*TEMPE	МЕ
	RIL(K)=(TEMPH-TEMP)/TEMPI	ME
	ROL(K) = (TEMPK-TEMP)/TEMPI	ME
	46 THETAX(K+1)=THETAX(K)+ DELTHE(K)	ME
in Section 2017	name in a consideration and the second superior of the second superi	an and the E
	48 N=N+1	ME
-	LB=LA+1	ME
,	LA=LLA(N)	ME
	· - · · · · · · · · · · · · · · · · · ·	
	TEMPH=UO	ME
Arthur petrolis		
	TEMPK=0.	ME
	GO TO 49	МЕ
	47 M=5	
	LBELA	sendents probably aprovation is 1,000 the 1
	DO 70 K=1,LB	
i destili sedidani		tarase Soft allemand and common wi
P	501 CORAA=CORA(5)+6.283184	
	IF(THETAX(K)-CORAA)-71-,7-3-,72	AN MINISTER CONTRACTOR OF SECURITY CONTRACTOR
	502 IF(THETAX(K)-CORA(M))71,73,72	
	7-1-ANGLE (K)=0.	AND TOTAL CONTROL PRODUCTION CONTROL C
	GO TO 70	
er especialism	$ = \frac{1}{2} \left(\frac{1}{2$	de conferma i Matematic consideration de condu
	575 IF(M-9)75,576,576	
	576-ANGLE(K-1)=CORAA	entine management and a state of a
a	GO TO 577	
	75-ANGLE(K-1)=CORA(M)	MORRESONAL PROPERTY OF THE PRO
}	577 M=M+1	
AND		TENNESTE TELEFONISCHE SEIN N. T. 407
	73 ANGLE(K)=0.	

							* * * * * * * * * * * * * * * * * * *	
	· 70	M=M+1 CONTINUE			9 N			
	•	IF(M-8)74,77,78.		and the same of th		a dan samen da mini traminut a umamun ngamun nga mang mang mang mang mang mang mang	Manacata Contrador Actividado (Actividado Actividado	And and Annual Section of Annual Section Conference on Security
-]		- ANGLE (LB) = CORA(M)	And the second control of the second	t of the first subsequent was well as the subsect of the Statistics (special angular in 1944).	dderstacid, in their etti stockelike itt i ittoligenders pelikellischepelisch	ion commendendendendendendendendendendendendende	Union के बार कर कर कर कर कर की का किए की के बात कर की प्रतान कर की प्रतान कर की प्रतान कर की प्रतान कर की प्रत 	महोत्र प्राप्त के सम्बद्धाः स्थापना एक प्रति प्राप्त का व्यवस्था है। व्यवस्था विकास स्थापना विकास स्थापना विकास
and the second		CONTINUE IMAX=XIMX	Zoner kartenin kalendaria (1904) eta pirangan kana kara kara kata kara kara kara kara kar	erannan erasyu toʻsakara nazishi masarangan ilmin baratan ta	attacompositivo (inconsistanti provi) sanno destino apartizza estimatori (inco	an of the state of	Andrews are applicable to the control of the contro	Tinar (Autorioration) pilotopia (1070) sa
		IMAXP=IMAX+1						
and Villianian area		DELX=XLENGT-/X-IMX- L2=2*LB	and the second				AMPHICONIONAMONTARIA MENTARIAN INTERNALIA	
-		-ITOT=900/L2			man ikan sarang da bahasan sarang manahan sarang sarang sarang sarang sarang sarang sarang sarang sarang saran	rendamber han metic suddiems sodbud entdebook rephalisa is in it grouped i	VV точного нашнова изпавальных пинарутов и	
pany atour browning commit	ma assissione agreement 4	RETURN 	eneroka o kolonijskim kritini kolonijski polivina o kolonijski provincija.	en en 11 september 18 september	r de la constante de la consta	altako anekatorikatorika katologia		MESH
	76	FORMAT (17HO BLO	W UP IN ME	ESH)				
		-LERR=1 RETURN				an alkan daham an anahan ilah serga yang ar par zar zar zar zar zar a bah kudiban bah	(fig. co.) (an all and fig. co.) (and fig. co.)	Province and a second s
- 4		END	makaniya unquanida ilkada dan dan meladakirin.	and the second s	uan a <u>tan manan ke pilan Bungaba katan men</u> nisas	trop unto yan mendangan kada salah salah sangan dan visis kanangan ki sana	Handesteller state state of the	MESH
	soloniamos (amplicable) terrotristo (metrocrassion)	3 1887年(18 · 8 · 8 · 8 · 8 · 8 · 8 · 8 · 8 · 8 ·		intersons promotes trobes from manuscript and significant	est a substanting bestely statement for the material statement	indiana sa sa kanana kanan	Medianisteriossosiaphispologicistribus colmonomis	THE CONTROL OF THE PROPERTY OF
. (mal	•							
1						eligen den version en en en de la recorda en en de la production de la production de la constante de la recorda	No. of the control of	Handing Andrew Committee Committee (Committee Committee Committee Committee Committee Committee Committee Commi
-	amana ji Samurani.	er eg met grekerken er vivor vor grenne syn spennen gemen het het de en en en fet betrekken en de grenne gêr gem		navojas vinterimo karakterimo na traditi — na registra de productiva de la compositiva della compositi		and the last of the state of th	Northwest State (State Vision) has being berneith in committeel of the	
	produción insulation de la constitución de la const	тап тап да тита не на на на на на да до приме в муста по на да до не прет старата по применения бого да на на н По на	an samulum makakan mengalan dan pangan makan sakan menanggalan	man un multage do centralesco de confuencia (de la populación	TY TECHNOLOGIST SANSKAPAN ING ANGESTI SANSKAPAN SANSKASA	era azartenebunina ibana. Sor beferantik ingelerik	the street, also whole so the state of the manufacture of the state of	organismostaler oldako, aktoren 16 miliotako eta
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STBFTC MESHA LIST, DECK, REF, DD, XR7
      SUBROUTINE MESHA(A, CENX, CENY, PLEBAK, PLEIN, NODE, IX, L2)
     COMMON Z
      DIMENSION Z(20000), ANGLE(100), RIL(100), ROL(100), ZA(200), THETAX(100)
     Ty,A(IX,L2),GENX(IX,L2),CENY(IX,L2),PLEBAK(IX,L2),PLEIN(IX,L2),
     2 Ib(100), IE(100), NODE(IX, L2), CORR(8), XPNT(100), YPNT(100)
     3,XZ(4),YZ(4),AY(6),AX(6),MA(10),CORA(8)
      EQUIVALENCE (Z(5201),R),(Z(5203),DELR),(Z(5816),ANGLE(1)),
     r(z(5200),LB),(z(5916),RIL(1)),(z(6016),ROL(1)),(z(2),IOUT),
     2(Z(11), LERR), (Z(627), ZA(1)), (ZA(4), UO), (ZA(5), VO), (ZA(6), U),
     3(ZA(7),V),(Z(5716),THETAX(1)),(Z(5202),THETAV),
                          (Z(6116), IB(1)), (Z(6216), IE(1)),
               EQUIVALENCE (Z(11816), YPNT(1)), (Z(5204), RP), (Z(5205), KRET),
     <u>+-(-Z-(-5700-)-»@URA(-+-)-)-, (-Z-(-5400-)-</u>, NGOA)-»-(-Z-(-5486-)-»-YE-)-»-(-Z-(-5492-)-» XE----»)-»
     2(Z(5487),YF),(Z(5405),ITE),(Z(5406),NGOB),(Z(5493),XF),
     3(Z(5407),IY4),(Z(5408),IY3),(Z(5409),IY2),(Z(5410),IY1),
     4(Z(5411),IX4),(Z(5412),IX3),(Z(5413),IX2),(Z(5414),IX1),
     5(Z(5415),NGO),-(-Z-5416),AA),-(-Z-5417),CENYA),(Z(5418),CENXA)--
     6(Z(5419), MA3), (Z(5420), MA2), (Z(5421), MA1), (Z(5422), JX),
     7-(Z-(-5423-)-•THE3-)-•-(-5424-)-•THE2-)-•-(-Z-(-5425-)-•THE1-)-•-(-Z-(-5426-)-•-RO3-)-•-
     8(Z(5427),RI3),(Z(5428),RO2),(Z(5429),RI2),(Z(5430),RO1)
     (Z(5445), MDU), (Z(5446), MCU),
     1(Z(5443),MG),
     2(Z(5447),MBU),(Z(5448),MAU),(Z(5449),PV),(Z(5450),PU),
     3(Z(5451),YFP),(Z(5452),XFP),(Z(5453),YEP),(Z(5454),XEP),
     4(Z(5455),YUP),(Z(5456),XUP),(Z(5457),YCP),(Z(5458),XCP),
     5(Z(5459),YBP),(Z(5460),XBP),(Z(5461),YAP),(Z(5462),XAP),
     6(Z(5463),KB),(Z(5464),K),(Z(5485),YD),(Z75491),XD),(Z75484),YC),
     7(Z(5490),XC),(Z(5483),YB),(Z(5489),XB),(Z(5482),YA),
     8{Z(5488),XA),{Z(5473),J),{Z(5474),YZ(1)),{Z(5478),XZ(1)),
     9(Z(5482),AY(1)),(Z(5488),AX(1)),(Z(5444),NG)
     -NAMELIST/NAM7/IB, IE, XPNT, YPNT-
      REAL LENGTH
      LB2=2*LB---
      DO 2901 J=1,LB2
      -I B ( J-) = 0-
      IE(J)=0
 2901-CONT-INUE
      I = 2
    ---GO TO 705-
1703 DELR=RP*THETAV
  --- R=RP
 705 RP=R+DELR
  701 K=J
    --IF(I-15)704,704,1026-
  704 A(I,J)=.0
     CENX-(-I 9-J-)= • 0-
      CENY(I \rightarrow J) = \bullet O
      PLEBAK(I,J)=+0-
      PLEIN(I,J)=.0
      GO-TO-102-
  104 CALL POINT (R, THETAX (K), XA, YA, 1.)
      CALL-POINT (R, THETAX (KB), XB, YB, 1.)
      CALL POINT (RP, THETAX (KB), XC, YC, 1.)
      GO TO 109
```

```
102 IF (K-LB) 3, 4, 4
   4 Kb=1----
     GO TO 104
 ---3-KB=K+1----
     GO TO 104
109-CONTINUE-
     IF(ANGLE(K))300,300,301
 300 KRET=0---
     ANGLE (K) = .0
     GO TO 105
 301 IF(R-CORR(5))101,4083,4083
4083 ANGLE (K)=.0
     GO TO 300
 101 XAP=XA
     KRET=1
     XBP=XB
     XCP = XC
     XDP=XD
     YAP=YA
     YBP=YB-
     YCP=YC
     YDP=YD-
4082 CALL POINT(R, ANGLE(K), XEP, YEP, 1.)
     PU=(U0+U)/2.
     PV = (VO + V)/2
     XZ(1) = XEP
     YZ(1) = YEP
     XZ(2)=PU-
     YZ(2)=PV
     XZ-(-3-)-X-CP-
     YZ(3) = YCP
     XZ(4) = XDP
     YZ(4) = YDP
     CALL INTER (XZ, YZ, XFP, YFP)
4081 RI1=RIL(K)
    ---RO1=ROL(K)-
     RI2=RIL(KB)
     RO2=ROL(Kb)
     RI3=CORR(5)
     00 4001 JX=1,4
     XL=XXL
     -IF(CORA(JX)-ANGLE(K)-)4001-34002-34001-
4001 CONTINUE
4002-R03=CORR(JXX)-
     THE1=THETAX(K)
     THE2=THETAX(KB)-
     THE3=ANGLE(K)
     CC1=.1 *THETAV
4092 IF (THE3-THE1-CC1
                        14083,4083,4093
4093 IF (THE2-THE3-CC1 )4083,4083,4091
4091 XB=XEP
     YG=YEP-
     XC=XFP
     Y. G=YFP.....
     RIL(KB)=RI3
     ROL(KB)=RO3----
     THETAX (KB) = THE3
 -105-CONTINUE-
  WHERE IS A, 1 IN PLATE, 2 IN T/E, 3 OUTSIDE PLATE (OR NO PLATE)
     -I.F.(-R-R-IL-(-K-)-)6,7,9
   6 MAU=2
```

```
GO TO 8
   7-MAU=1
     GO TO 8
   9 IF (R-ROL(K)) 7,7,10
  10 MAU=3
 WHERE IS &
  8 IF(R-RIL(KB))11,12,13
  11-MbU=2-
     GO TO 14
  12-MBU=1---
     GO TO 14
  13 IF (R-ROL(KB))12,12,15
  15 MBU=3
 WHERE-IS-U-
  14 IF(RP-RIL(K))16,17,19
  16 MDU=2
     GO TO 18
  17-MDU=1-
     GO TO 18
  19 IF(RP-ROL(K))17,17,20
  20 MDU=3
 WHERE IS C
  18 IF(RP-RIL(KB))21,22,23
  21-MCU=2-
     GO TO 24
  22-MCU=1-
     GO TO 24
 23 IF(RP-ROL(KB))22,22,25
  25 MCU=3
 ~24~MZU=MDU+3*(-MGU-]~)+9*(MBU-1~)+27*(MAU-]~)~~~~~~
     GO TO (36,37,38,37,37,37,39,37,40,41,37,42,68,37,69,37,37,43,37,37
    -2 , 37 , <del>37 , 37 , 37 , 44 , 37 , 45 , 46 , 47 , 37 , 37 , 37 , 37 , 48 , 49 , 50 , 51 , 52 , 53 , 54 , 55 , .</del>
    356,57,58,59,37,37,37,37,37,37,70,60,61,37,37,62,37,37,37,37,37
    -463,37,37,64,37,<del>37,65,37,65,37,66,37,37,37,37,37,37,37,37,37,37,</del>
  37 WRITE(IOUT, 4069) MZU
4069-FORMAT(63H0bAU_bRANGH-IN-MESH-CALGorg-SUBROUTINE-MESHAg-STATEMENT-2----
    24, MZU=13)
    -LERR=1
     RETURN
497 NG=1- -
     MG = 100
504-IF (NAA . L.T . 2*MG) GO-TO-500
     IF (NAA.LT.3*MG)GO TO 501
     IF (NAA.LT.4*MG)GO TO-502
     IF(NAA.LT.5*MG)GO TO 505
     IF (NAA.LT.6*MG)GO TO 506
     MA(NG) = 6
    -GO-TO-503-
505 MA(NG) = 4
   ---- GO-TO-503-
506 MA(NG)=5
     GO-TO-503
502 MA(NG)=3
 ----GO-TO-503-
501 \text{ MA(NG)} = 2
    -GO-TO-503-
500 \text{ MA(NG)} = 1
503 NAA=NAA-MA (NG) *MG-
     MG=MG/10
     NG=NG+1-
     IF(NG.LE.3) GO TO 504
```

```
MA1=MA(1)
      MA2=MA(2)
      MA3=MA(3)
     CALL AREA(AX(MA1),AX(MA2),AX(MA3),AY(MA1),AY(MA2),AY(MA3),AA,CENXA
     2 . CENYA)
      AA+(C,I)A=(C,I)A
      CENX(I,J) = CENX(I,J) + CENXA*AA
      CENY(I,J)=CENY(I,J)-+-CENYA*AA-
      GO TO NGO, (510, 511, 512, 513, 600, 515, 517)
CASE 8
   36 IX1=1
     -IX2=4
      IX3=1
      -IX4 = 2
      NODE(I,J)=5
     -ASSIGN-901-TO-NGOB
   36 ASSIGN 510 TO NGO
      -NAA=123-
      GO TO 497
  510-ASSIGN <u>511-TO-NGO</u>
      NAA=134
     GO TO 497
  511 IY1=IX1
      -IY2=IX2-
      IY3=IX3
      IY4 = IX4
      ZZX
                  =LENGTH(AX(IX1),AY(IY1),AX(IX2),AY(IY2))
      PLEBAK(I,J)=ZZX+PLEBAK(I,J)
                 = LENGTH(AX(IX3), AY(IY3), AX(IX4), AY(IY4))
      PLEIN(T,J)=ZZX+PLETN(T,J)
      GO TO 600
CASE 1
   51 IX1=1
      IX2 = 4
      IX3=1
      -IX4=2-
      NODE(I,J)=I
      ASSIGN 901-TO NGOB-
      ITE=1
  950 IF(ITE)1002,1001,1002
 1001 CALL POINT (ROL(K), THETAX(K), XA, YA, 1.)
      -CALL-POINT-(ROL(KB)),THETAX(KB),XB,YB,1-)
      GO TO 836
 1002-CALL-POINT-(RIL(K))THETAX(K),XA,YA,1.)
      CALL POINT (RIL(KB), THETAX(KB), XB, YB, 1.)
     -GO-TO-836
CASE 2
  ~46-IX1=6
      IX2=4
      1X3=6
      IX4=5
      NODE(-I-,-J-)=1----
      ASSIGN 901 TO NGOB
      un [-T-E-=-] ausseria inclusione de
  846 ASSIGN 512 TO NGO
     -NAA=2-35-
  951 IF(ITE)1003,1004,1003
 1004 CALL POINT (ROL(K) -THETAX (K) -XF -YF -1 -)
      CALL POINT (ROL(KB), THETAX(KB), XZ(1), YZ(1), 1.)
      GO TO 516
 1003 CALL PUINT (RIL(K), THETAX(K), XF, YF, 1.)
```

```
CALL POINT (RIL(KB), THETAX(KB), XZ(1), YZ(1),1.)
  516 XZ(2)=XF
      YZ(2)≈YF
      XZ(3)=XA
      YZ(3)=YA
      XZ(4)=XB
      YZ(4)=YB
  618 CALL INTERTXZ, YZ, XE, YE)
      GO TO 497
  512 ASSIGN 513 TO NGO
      NAA=356
    GO TO 497
  513 ASSIGN 511 TO NGO
      NAA=346
      GO TO 497
CASE 3
   41 IX1=1
      -1 \times 2 = 4
      IX3=5
      IX4=6
      NODE(I,J)=I
      ASSIGN 901-TO-NGOB-
      ITE=1
  NAA=156
  952 IF (ITE) 1005, 1006, 1005
1006 CALL POINT(ROL(KB), THETAX(KB), XF, YF, 1.)
      CALL POINT (ROL(K) -, THETAX(K), XZ(1), YZ(1), 1.)
      GO TO 516
-1005-CALL-POINT(RIL(KB))>THETAX(KB)>XF>YF>1-)
      CALL POINT (RIL(K), THETAX(K), XZ(1), YZ(1), 1.)
      GO TO 516
  515 ASSIGN 517 TO NGO
      NAA=136 -
      GO TO 497
  5-17 ASSIGN 511-TO-NGO-
      NAA=134
   - GO-TO 49-7 ---
CASE 4
 --54 IX1=4 --
    IX2=6
     -IX3=5---
      IX4=6
      NODE(I,J)=1---
      ASSIGN 901 TO NGOB
   -- ITE=1
  854 ASSIGN 511 TO NGO
    NAA=456
  953 IF(ITE)1007,1008,1007
 1008-CALL-POINT (ROL(K),THETAX(K),XF,YF,1.)
      CALL POINT (ROL(KB), THETAX(KB), XZ(1), YZ(1), 1.)
      GO-TO-1009
 1007 CALL POINT(RIL(K), THETAX(K), XF, YF, 1.)
      -CALL-POINT(RIL(KB)),THETAX(KB),XZ(1),YZ(1),Ta)
 1009 XZ(2) = XF
      YZ(2)=YF
      XZ(3)=XC
      YZ (3)=YC
      XZ(4) = XD
      YZ (4) = YD
      GO TO 618
```

```
CASE 5
52 IX1=1
      IX2=1
      IX3=5
      IX4=6
     NODE (I . ) J ) = 1 w southwarm our
      ASSIGN 901 TO NGOB
      ITE=1-
  852 ASSIGN 511 TO NGO
      NAA=356--
      IF(ITE)1011,1010,1011
 1010-CALL POINT ROLLKBY, THE TAX (KB), XE, YE, 1.)
      CALL POINT(ROL(K), THETAX(K), XZ(1), YZ(1), 1.)
      GO TO 1012
 1011 CALL POINT(RIL(KB), THETAX(KB), XE, YE, 1.)
      CALL POINT (RIL(K), THETAX(K), XZ(I), YZ(I), 1.
 1012 XZ(2) = XE
      YZ (2)=YE
      XZ(3)=XC
      YZ(3)=YC
      XZ(4)=XD
      YZ(4)=YD-
      CALL INTER (XZ,YZ,XF,YF)
     -GO-TO-:97-
CASE 6
  -47-IXÍ=l-
      1X2=4
      -IX3 = 1
      IX4=2
     --NODE (-I , J ) = 1 -----
      ASSIGN 901 TO NGOB
    847 ASSIGN 520 TO NGOA
 -955-IF(ITE)-523,1014, 523
 1014 CALL POINT(ROL(K), THETAX(K), XZ(1), YZ(1), 1.)
   GO TO 1013
  523 CALL POINT (RIL(K), THETAX(K), XZ(1), YZ(1), 1.)
      CALL POINT (RIL(KB), THETAX(KB), XZ(2), YZ(2), 1.)
 1013 XZ(3)=XA^{-}
      YZ(3) = YA
      XZ(4) = XB
      YZ(4)=YB
      CALL INTER(XZ,YZ,XE,YE)
      XZ(3)=XC
      YZ(3)=YC
      XZ(4)=XD
      YZ(4)=YD
      CALL INTER(XZ,YZ,XF,YF)
      GO TO NGOA, (520,522)
  520 XA=XE
      YA=YE
      XD=XF
      . Y D = Y F
      GO TO 836
CASE-7-
   68 IX1=1
      -I-X2=4-
      IX3=1
      -I.X.4= 2 ----
      NODE(I \rightarrow J) = 1
```

```
ASSIGN 901 TO NGOB
  868 ASSIGN 522 TO NGOA
      GO TO 955
  522 XB=XE
      -Y6=YE
      XC = XF
      Y C=YF-
      GO TO 836
CASE-1P---
   40 IX1=1
      ~IX2=4~
      IX3=1
      -I X4=2----
      NODE(I,J)=3
      -ASSIGN-901-TO-NGOB-
  840 CALL POINT (ROL(K), THETAX(K), XD, YD, 1.)
      -CALL-PUINT-(ROL-(KB)) THE TAX (KB) , XC, YC, 12-7-
      GO TO 836
CASE 2P
   45 IX1=1
    ---IX2 = 6
       IX3=1
      -I X 4=5-
      NODE(I,J)=3
      ASSIGN-901-TO-NGOB
      ITE=0
  845 ASSIGN 511 TO NGO
      NAA=156
   ---GO-TO-951-
CASE 3P
  -63 - IX1 = 1
       IX2=1
      -I \times 3 = 2 - - - -
       IX4=5
      -NODE (-I-,-J-)=3----
      ASSIGN 901 TO NGOB-
      --ITE=0---
  863 ASSIGN 511 TO NGO
      NAA=256---
      GO TO 952
CASE 4P
   38 IX1=1
      -IX2=6
      IX3=1
      IX4=2
      NODE(I,J)=3
      -ASSIGN-902-TO-NGOB-
      ASSIGN 1836 TO NGOC
      ITE=0---
      GO TO 854
CASE-5P-
   39 IX1=1
      -IX2=4
       IX3=1
      -I-X-4=-2-
      NODE (I,J)=3
      ASSIGN-902-TO-NGOB-
      ASSIGN 1836 TO NGOC
       -I-TE:=0-
       GO TO 852
```

	CASE 6P					
	44 IX1=1	ad Blackets (Mell's el Telenard d'entrandre descriptor de marquet en 1700 de l'artiféra de la collection de l Collection de l'Artiferant d'entrandre de l'entrandre de l'e	teller dem stellningsjessegges verkom eller teller (sp. v springsistened sel sivis	irida ka kesik ilmedi (in - mendi ilik ilmidi negari mengelih mendingan probinsis	nyandahanpinyahan 1994-kin sajal oleh mendapil di Appada dappannyanaka	Processistante de la company de la compa
	I X 2 = 4					
-	I X 3 = 1	gar satri) nepum aptartuga gaptangan menurapka aktibi yi pag aminotok menungkan daga gasajar aptama	alia menging ingaminggapan metambahan inga salah sasa	rasak nyiponena ensikurunna samakiyen meknasuna ()	a y tank a kummanyi memmenendak yi miya mendenya ingkenguanyang anganasiya.	Central Control (Control Control Contr
(3)	IX4=2					
CLOS	ACCACAL COLUMN	mer and president and representations of any Properties of any Properties of any present estimates and any present estimat	entra en en en entra el transferio de la companya del la companya de la compa	isto regularismente dell'Arcidi St. II. distribi P. dell'Arcidito.	er - apterber ombe aktor tre kommer energialistikation	BERTHER TO STANFORD STANFORD THE STANFORD OF STANFORD
	ASSIGN 901 TO NGOB				4	
	GO TO 868	a an indicate and a second	Service of the servic	And the second s	Contra delimentario della compania della contra della con	programme and programme in the programme of security or an extendible for the con-
				annegan a resistat antilane es sent es control es e		
	62 IX1=1					
		a governo mento con la cocumiente del cinida en esce esta del care della constanta della constanta della const		Nicona streetism taat ustiinken kiin verske esteed in 1914.	nymany (Million essa Com), walke kao kuki (College constalla Julion Com)	Commenciary and the State Commence of Control of State (State Control of Cont
and the second s	I X 3 = 1					
	1X4=2		***************************************	anter anno de marco de la companio	Managapan da	indunación de la companya de la comp
	NODE(I,J)=3					
8.3	ASSIGN 901 TO NGOB		***************************************	and purchased special strategies of service designations of services and services of services of services and services of services and services of services and services are services and services are s		poliny construction for the legislature on the principal of the legislature and productive and principal of the legislature and the legislature an
N-10-77%	ITE=0					
a la	missississississississississississississ	and a second discount of the second s	a Brioth supringer produce of the project spines which he	T BELLER ST. CONTROL OF THE POSSIBLE OF THE STATE AND ADDRESS.	on materials of the confidence in the confidence of the confidence	angelikkele film S. a. et selegaanis samme kalke et militaris megalistis et klassel.
Lal	CASE 3-4PP					
	42-IX1=4	naja adalam di distan a (da distanda i magan fan de si de a que a en a tradition (da), a de grade anticon (de se	an ang kananan yang ang ang ang ang ang ang ang ang ang	Mily or Supplier outputs into open the Strate gappy of adjust the second of	s derfolkten forgräftliche kap (k. v.), der ein hollste kommunisation und kraufe (adm self	endergradusseje-forgitystocki telektrios, daustocki soverescom och 14 g. yver, av iskalidikstissisket
	IX2=6					
1.]	IX3=1	essential and the second and the sec	van 1775 a. s. andre jud dispersión de termen unique subsepte d'april	a Programmin agricultura de destructivo de de Militado es a especía de estado de Militado es a estado de destructivo de de destructivo de des	ediaterradialismahibilisegerjumpurunka akun salumpuruska salumber	minum composition del reputation in management respectively acceptations
1	I X 4 = 1					
V. President sounds	error arrangement are recovered M.O.D.E. (In.) and a) and a few arrangement recovering encourage encouragement	SECURITION OF THE PROPERTY OF	and a processing to the last the supplemental to the last	ndoksinistiismistoismistoimistoimistoimistoimistoimistoimistoimistoimistoimistoimistoimistoimistoimistoimistoi	entire se responsable in communication and activation of the contraction of the contracti	idi proporeti il sendenge as rendrat raproparti, pengene sensi delak
	ASSIGN 902 TO NGOB					
3	ITE=0	parameter and the second se	tar - control act activities and antiques		en ten ta annumenta - epitan - en estaggi - en estaggi - en estago de este en anticoportigio de estago.	gangagessenerin (Carangagesener-regenjera) kilijigesener-reddi sor
) in	ASSIGN 970 TO NGOC		•			
-	GO TO 854	entransferrent findere med eksterrentspropt for an over menseet at attentionspropt at a second	هد به دایکیدرینیه به باهچه دستهانامت میسیدین به میشد.	a englangen kepangan periodakan periodakan periodakan dina kepita ang	- Anniell contract of application were contract to the contraction of the contract of the cont	ing pangganana, semanan manggan panggan panggan panggan panggan penggan penggan panggan panggan panggan panggan
J	CASE 3-1PP					
months of the second	x_{ij} and x_{ij} and x_{ij} and x_{ij} and x_{ij} are x_{ij} and x_{ij} and x_{ij} are x_{ij} and $x_{$	missenskinst elikaristerinskingerinsketer 1900 f. in trokepester mettyle gat, som fra 1900	er de la comercia de la compansión de la comercia del la comercia de la comercia del la comercia de la comercia del la comercia de la comercia de la comercia del la c	ellegy etrophysiocentro. To a tropped ellegistratiquis petr	ar der werd bereicht der v. 1000 bereicht auf an der der	endagos o despet is espetial metalistical contential tales.
1).	IX2=6		•		•	
	I X 3 = 1	in the support of the	energia arappara provincia de la composición del composición de la composición de la composición del composición del composición de la composición del		2 . Service medicappearings and and	promising and in the first state of the stat
	IX4=1					
-	NODE(I,J)=4	aasaan mirramaa maasaa yy maa maarindan dee ir adayaadan siirkii ir yo oo ee ee maa kirraacaa mirramii seenii	10. A completely seem is an exercise in proceeding the process of process of the complete of t	energe energy and a second second	амен апапта ес эт (т. т.т.) — «С. т. р. — «С. ав ^з асториятальная установа установа.	entropies and the commentation of the second
	ASSIGN 902 TO NGOB					
promotive strong continu	CONTRACTOR NO CO	ntanuarioannapapion (c. a. 1900)	ing tempapan persembah merandakan pendangkan berakan pendangkan berakan pendangkan berakan pendangkan berakan	Maritimense antologi Pia viskui sekkitoset sõhettyseks	erja engelegen (i.e., i.e., i.e.	- Ber 1970 (Marketter 1986) and 1980 (Marketter 1986) and 1986 (Market
la y	ITE=0					
	GO TO 950	eli parimpility di la maria mpi mangan mangan mengan mengangan kepangan kepangan di berbah Mangangan di Pandapan sad		at the street street and a street of the str	a requirement of the control of the	- Life traditional characteristic alleganistic properties of
The state of the s	CASE 2-5PP					a
	48 IX1=1	and and a state of the second construction of the second 	yr rentib fyragun aglegete stellföllitikkapatoptinpagnilliste miller		kapakagalapakan kalimeren hadi gi yangan persaman yant e e ingelet ing yang pengepanan (bir esi), ebi isang	e territorio de anticologica de la companiente de la companiente de la companiente de la companiente de la comp
	IX2=1					
ET MANAGEMENT MANAGEME	enterente de la composition della composition de	en e	e en majori propriori della Tarritte di Primi di	dryg atlantingsvestartovalismist proprietire etmorrenerie	rysy eo rithauthatha Salyanagaiste-marken i samanganikesta anaminjatenakan	er comit i konsulyatahan, selatahanan katalahan kelologian dari basikan kelologian dari basikan basikan basikan
	IX4=1		.•		·	
	NODE (1,J)=4				and the second s	organism representative, our provincent electronics in account of 5 metrics - Francisco elec-
	ASSIGN 902 TO NGOB		·			
	ASSIGN 46 TO NGOC					,
10	ITE =0					
	GO TO 8:52					
- options	CASE 6-5PP					
63	49 IX1=1					
	I X 2 = 1 I X 3 = I			nggangangangan pada samannan banasan sasa sasa na 10 Marini Paus pana	nyventralistististististististististististististi	A
(a.9)	IX4=1					
from the commencer and the	$1 \land +-1$	gympismäädi Karpassaja jääskavatude kirjoin van annostantiin Mossen esperiade. Dine	edo) grazona orane okok - z- , suzen biolikokk	ografiak@distribute@distribute.com/code/com/article/com/	-Propertieska omissaa et siidateen ettäättä kyrjoi valketaitiini. Assa	elember (Steater Production and Steater Steater)
	ASSIGN 902 TO NGOB					
	ITE=0	manuskinnika, jaga saja sene seki perega semeneleh a kingman dakumen	e ogsagnesis og kritis i stjer i mysketteligere	and the second second second second second	and it make replaced to the control of the control of the state of the	angeneral ligeraria di galazione an ingan que relicione los negativos est. est.
	ASSIGN 47 TO NGOC					
		ne dispense proposition and proposition of the second seco	ngan spongangan ani diseri i i i kin i i in 1 si maga	appen spragrampromanager e - only more in a	Section (1994) - 1900 -	n digita talan ayun galah. Ayun kan kandunan gar san, senagiliking sebengai seri yan diging
! }	CASE 2-1PP			`		
THE RESERVE THE PERSON OF		ak ka sakan dan gersepangan dalam salam sakan menganggan kelabukan dan dan pendagan dalam salam salam dalam sa	egan dana - iranjahan p.a. natrono ningga ing niga	ggyapanapapapanapanapanasis ya sayong a berakan ya sayong	pri - V Arts Jerg erablikalengenassasskipte heger	programme of the comment of the comm
	IX2=6					
-		ر در از در			energian e e e e e e e e e e e e e e e e e e e	antiganicionas ministrio aparatina praesantinistri di Praesana registro con cos
1 1 3 Y						

```
IX3=1
      IX4=1
      NODE(I_{J})=4
      ASSIGN 902 TO NGOB
      ASSIGN 972 TO NGOC
      ITE=O
      GO TO 950
CASE 1-4PP
   53 IX1=6
      TX2=4
      IX3=1
      IX4=1
      NODE(I,J)=4
      ASSIGN 902 TO NGOB
      ASSIGN 973 TO NGOC
      -I-T-E=0-
      GO TO 854
CASE ALL TYE
   55 NODE(I,J)=-1
      ASSIGN 901-TO-NGOB
      GO TO 600
CAST 4-4PP
   56 IX1=4
     -IX2=6
      IX3=1
      -I \times 4 = 1
      NODE(I,J)=4
      ASSIGN 902 TO NGOB
      ITE=0
      -ASSIGN-1974-TO-NGOC-
      GO TO 854
CASE 1-5PP --
   57 IX1=1
      IX2=1
      IX3=1
      IX4=1
      NODE(I,J)=4
      ASSIGN 902-TO-NGOB --
      ITE=0
      -ASSIGN-51-TO-NGOC
      GO TO 852
CASE 5-5PP
   58 IX1=1
      -IX2 = 1
      IX3=1
      . IX4=1
      NODE(I,J)=4
      ASS-I GN-902-TO-NGOB-
      ASSIGN 52 TO NGOC
      -ITE=0----
      GO TO 852
CASE-1-1PP-
   59 IX1=4
      -1 \times 2 = 6
      IX3=1
      IX4 = 1
      NODE(I,J)=4
      ASSIGN 902 TO NGOB
      ASSIGN 973 TO NGOC
      -I-T-E:=-0-
      GO TO 950
```

	CASE 6-6PP					
-	60 IX1=1 IX2=1	тыр/дараа 5.1883 (седа 1619), болордануун адам Элькомой эээ тоо оо доодоолоо доонуулгандагын байм оны 44.884 (nden Jampsaka Shipettoo: Makkan Kangayay ayanah asa intermatika hakki japey shipa a	áradinyskennom hikkeletakomennúva i jernériahabaksj	ermitere (6/5), etante lindration etatellan errore errore errore errore errore errore errore errore errore er	anni koji i metaliki.
	IX3=5	e manada meneral siden melanga, panggan kananggan peneral kalangan mengahan peneral siden melanggan banggan sa	rando despues (al arti artico es es esta en esca en	o i social metalolis telepetatipo teleperatura apostra spektra estatologica.	int arasissiste in teleprocessississississa ja process yayan kanaba sataran a sasa ya a ka	mocord, attention (m) corper
	IX4=5					
The residence projections	apper e imperiación casa está está (Life Life) = 100 mm ama una popular casa	nem statem materia en elektrolisten distration proposition et en en principal proposition de son	tetatorialist tipas bestäväisen poles on maanasis kun teen on	a taking the individual parameter street in the second	and the state of t	is interplant make one
	ASSIGN 902 TO NGOB					
	ASSIGN 971 TO NGOC-	والمتعارض	amera ne manta dila anta di anta de anta	and the second section of the s	i carrent interpresenta deposição qui especiante telentribulimo i contra francis de seguentariones de	perfection residence of
70,000	ITE=0					
13	GO TO 847	ina nanjar ayong Melek miga garas na nayar an Majiar bahayarah yila yayan sin da sebakhir kulikin da Pilik	e and the state of	care, compani, campé hiéri los agains a regay, campadició con étre éscullebos.	agua parahan salandahan kansan kalamin naguki dari salamin 1966, Abisan kansan dari kansan dari kansan dari ka Baran	antener oranieras artifects
	CASE Z-ZPP		encona licolo i inclui con i altigramente compresa i travera forti a constato	anner et aller en		adeli svijas Sauroviais (desa)
	IX2=6					
-0	IX3=1			erkáns, transportuje skietos sultro jugo majoros si transportus sunificiales sensitatis igen	n stadiografication of the conference of the con	CONTRACTOR OF STREET
	IX4=1					
2000	NODE (I) J) =4	والمنافزة المتعاون والمتعاون	namanan inga antikonominya ing kaliminga di antikonomini daki salihatika 1985 di kaliminga di antikonomini di	tari si namengalahirin 30 Samangan digasi situngan da katas nemperinteng	and the state of t	rappionos, Pelases (pilotes
1	ASSIGN 902 TO NGOB					
na zapadawiawiawi	MANAGER TO SERVICE OF COMMENTS OF THE SERVICE OF COMMENTS OF THE SERVICE OF THE S	umpermentalisti menetika sejenisti renimpere seminansekturimi ener i darah seban sa dibak beliatu.	katerapusationis (selanos servito) ejecus (c.) en fechenologie (en es circus anne e	x tolkinninsse villatige tilpestation i sena er t.e. e line,	trendrit de land armatelinde to toda trajecto toda trajecto trajecto trajecto de la secondita de la discolaración de la discol	Construction of the Construction
3	ITE=O					
		uurukkaan ja 1964 ka 1974 aastan 1974 ka 1974 k	akan pada kanga di anga at anga at di di di a nga mana di <mark>diakan palband</mark> kang A. di bada 1900 may ang maga ba	and the second second and the same partial of partial confidence of the same	andra kandra in gestle (1948, des est platific à transfer agrançant par esse project, en equit en la represident	Production of the Production o
	CASE 3-7PP 64 IX1=1			·	naarrinde (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1885) (1	Mark Courter Mountains
	IX2=1					
The second second		end Enclosive of the property of the control of the	augs papanananahadiminahagaan gaha paker dikum situsisp ésasas	construited in a more transportation and the production of the state of the second section of the section of	an addicina ana antana denomina in term in en	entra sauteranista
	I X 4 = 1					
· · · · · · · · · · · · · · · · · · ·	NODE (I , J) = 4		engagangapak ing memberah menerahang menggan panggan panggan menerahannan a mana anagga		independent general er forste de state de state La companya de state	ussain - royamonama
127	ASSIGN 902 TO NGOB					
-	ASSIGN-41-TO-NGOC-	والمرافقة والمرا	diginanar moderni ar ir	oria es e, manto-como presidentem e especialmente el internación de el internación d	жителен бет мунителерия (1866—1864 — 1864 —	ancer 21 - Printer Street
g made	ITE=0					
production and a	CASE 7-7PP	adoministrativos de directos estantis a e (1) — (1 + 1 e experiente vigales hape an neuro a	After country of the analogue of the plant of the property of the plant of the property of the	en per est en septembre de seus per per en	(1975年) 1985年 -	estra aspateito.
	65 IX1=1	all man community of the construction and the second seco	ndigestates havery and maliferbookhim, parastropeus vanis tandamin melakhimen k	adeligentarische paris (debyedigente generale ausselne generale) 1.72 g	странический тистин такий тому и некатору и на принаграмическую и некатору и на принаграмическую и некатору и	on disconnections
a second	IX2=1					
<u> </u>	1X3=1	m negeringen i som – ga a serge rakstelligter i ga engleger i kommenterer	e per una una mangamentamenta de la colon de la colonidade de la colonidade de colonid	er in einer ausgeber der der der der der der der der der d	engane mise se genere a - 2 a verspeare a a entreprimity antisonomies	reconservement i famor
	I X 4 = 1					
CALLES MINISTERIOR	se sentes estate per la company de la compan	estata	nak juga persamatatan sejeratu seri akapat api asi damahakatan dipusi dan 40 Ta	Carrie dinhami de protesió de pre Constante per Constante (Constante Constante). Constante (Constante Constante	n digentinantian (s. 1800) (s.	ment - morecular
ing .	ASSIGN 902 TO NGOB					
	ASSIGN 68 TO NGOC	anagang panasanagan pangang ap di salah pan ak - 19 (m. 19 pangan meli mendisi sembul sembul sepan	. ш. лар Ком. (1986) — 1990 до ментов муна муновит и той трассовацийн	teatropico Paris de Centra Carago, de Maria Antonio Carago, de Carago, de Carago, de Carago, de Carago, de Car	is a complete and provide an extension of the contract of the	cides ingstrat industrial
Contin	ITE=0	e de la composition della comp	no, visi to vantarino il comprene proporazione como cere nebenevità esseguine, anue	ma starinon interna marzantzaka centaki atkaren 1880a, gaza		anga To Assaul (Springspill)
· •	GO TO 868 CASE 3-3PP					
· June surrium	CUST D. D. L.	tambonasti entre esta esta esta esta esta esta esta est	rania - manas mari palmasaran ana anta anta anta anta anta anta a	Bloom maken menerala and an indicate an indicate an indicate an indicate and an indicate an indicate an indicate an indicate an indicate and an indicate an indicate an indicate an indicate an indicate and an indicate an indica	anjanjanas mendamanjan sasi jangan jangan penasaran menanjan galaman pela da jem	unite i curanto contrata
in the second	IX2=1					
-	I X 3 = 1	and the second	# 	and the second s	agalapanan mahamatikan tangin terpanangan sa menghangan sa menjah papahatan juga pang	ye supere. I nest confide
	I X 4 = 1					
	NODE(I,J)=4		a pydriwyniaddu y yddidd hyd ddillygga gyglan ganaen yn y drobbin byd hannannau		and the second s	and the second second second
	ASSIGN 902 TO NGOB					
ta Santa Santa Santa	in TE = 0	andralica (a balancia in para monta ari marin no despero ne de cienta que no cisto de la comercia de la balanc	AND AND CONTRACTOR CONTRACTOR AND SECTION OF THE PROPERTY OF A SECTION OF THE SEC	·····································	менину кан такжа прочет и из темперен из до несейте до несейте за предоставления и изгородите в прочет и изгор -	olor yeli dakinda jenestani
4000	GO TO 841					
	CASE ALL OUTSIDE PLATE					
	67 NODE(I-J)=0	and the second	angen sidangan pagamang pangang pangang kanyasan pangan sa terbisan sa pangan sa	en a m aterial de l'en care que agripe que l'agripe de l'agripe de l'agripe de l'agripe	د المعالمة المعارضة والمدروة المعارض والمدارسة المعارضة المعارضة المعارضة المعارضة المعارضة المعارضة المعارضة ا -	
; ************************************	ASSIGN 901 TO NGOB					
n. Armericani	and the second contract of the second contract of G . On the G . On the G . On the second contract of the s	entrativismuskinintervierie 🗠 - intellimistikkusininterviesies ja	atalianapida maginto trono mananar manano o propinsi mono de to più	epi kanji sipi-stanis i pije takan jiping dipina matiki P Z rapin s	anna de la company de la c	(417) #47) 417 (386) **
	CASE 7-4PP			,	•	
	69_IX1=4	ggypalainga prophaeth (1974), 4, 1276, gdd Agart mighriwr ab ma rhae sabhagan thaeth (1984), bad bhi an a	sagaragnama, ennigemente reimuna, essa mainre ensessa sus en el		est lada bilantulun est dell'illumituda dage mangalan de le etn (persituar net liberaga citem	YSUTURNS, NORTH MAN
	IX2=6			•		
 	[X3=]	·····································	والمراورة	ran (1986) (1986) (1986) (1986) (1986) (1986) (1986) (1986) (1986)	and the state of t	r (ang agus shu). I think dig t filleran
	I X 4 = 1					
THE PERSON NAMED IN COLUMN	ASSIGN 902 TO NGOB	and the second s	And the second is a second of the second	men mel season interview or the college of the college (1998)	norman and an annual service and annual conference of the property of the pro	na njejme jedi 20 00 (189 4)
	70010H 902 TO HOOD			entigen terminologic brains the entire of the equipment of		Wester Commission
- W						

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ASSIGN 974 TO NGOC
      TTE=0
      GO TO 854
CASE 2-6PP
   70 IX1=1
      -I-X2=1
      IX3=1
      IX4=1
      NODE(I,J)=4
      ASSIGN-902-TO-NGOB-
      ASSIGN 46 TO NGOC
      . I.T.E.. O............
      GO TO 847
  600-GO-TO-NGOB, (901,902)
  901 IF(KRET)106,108,106
  106 KRET=0
      XA=XEP
      YA=YEP
      XD=XFP
      YD=YFP
      Xb=XBP
      Yb=YbP
      XC=XCP
      YC=YCP---
      ROL(K) = RO3
      RIL(K)=R1-3-
      ROL(KB) = RO2
      RIL(K6)=RI2---
      THETAX(K)=THE3
      THETAX (KB) = THE 2-
      PBAK=PLEBAK(I,J)
      NIJP=NODE (-I,J)
      GO TO 105
  108 IF (ANGLE(K)) 107,107,1015
 1015 PLEBAK(I,J)=PBAK
     -XA=XAP---
      YA=YAP
      XD=XDP
      YD = YDP
      RIL(K)=RII
      ROL(K) = RO1
      THETAX(K)=THE1
      IF(NIJP-4)5024,5025,5024
 5024 IF(NODE(I,J)-4)5026,5025,5026
 5025 NODE(I,J)=4
   -- GO TO 5027-
 5026 IF(NIJP+1)5029,5028,5029
 5028 IF(NODE(I;J)+1)5029*5031*5029
 5031 NODE(I,J)=-1
     --GO-TO-5027--
 5029 NODE(I,J)=1
 5027-CONTINUE-
      GO TO 107
  902-A-(-I-,-J-)-=-A-(-I-,-J-)-------
      CENX(I,J) = -CENX(I,J)
      CENY(-I,J)=-CENY(I,J)-
      ASSIGN 901 TO NGOB
      -GO-TO-NGOC+(836+970+971+46+972+973+974+51+41+68+1974+1836)-
  970 PLEBAK(I,J)=-PLEBAK(I,J)
      GO-TO-41-
  971 PLEIN(I,J) = -PLEIN(I,J)
```

```
GO TO 47
972 PLEBAK(I,J)=-PLEBAK(I,J)
     GO TO 46
973-PLEBAK(I,J)=-PLEBAK(I,J)
     GO TO 51
 974-PLEBAK(I,J)=-PLEBAK(I,J)-
     GO TO 68
1974 PLEBAK(I,J)=-PLEBAK(I,J)
     GO TO 54
1836 - IX1=1
     IX2=1
    -1 \times 3 = 1
     IX4=1
    -GO-TO-836--
 107 CENX(I,J)=CENX(I,J)/A(I,J)
   ---CENY(I,J)=CENY(I,J)/A(I,J)---
     IF(IB(J))1016,1017,1016
-1017-IF(NODE(I-)J-1-1-1-019-1018-1018---
1018 \ IB(J) = I
1016 IF(NODE(I,J))1021,1020,1021
1020 IF(IE(J))1021,1022,1021
1022 IE(J)=I-1
     GO TO 1021
1019 IF(NODE(I3J))1021;1023;1021
1023 \text{ IB}(J) = -1
1021 IF(I-IB(J))1701,2023,1701
2023 CALL POINT (RIL(K), THETAX(K), XZ(1), YZ(1), 1.)
     CALL POINT (RIL(KB), THETAX(KB), XZ(2), YZ(2), 1.)
     XZ(3) = CENX(I,J)
     YZ(3)=CENY(I,J)
     XZ(4) = (UO+U)/2
     YZ(4) = (VO+V)/2.
     CALL INTER(XZ, YZ, XPNT(J), YPNT(J))
1701 IF(J-LB)1024,1025,1025
1024 J=J+1
    -60-T0-701
1025 DO 1026 J=1,LB
 ---IF(IE(J))1027,1027,1026
1026 CONTINUE
  -- RETURN -
1027 I = I + 1
    -- IF (-I-IX---) 1703, 1029, 1029
1029 WRITE(IOUT, 1030) -
1030 FORMAT (22HO TOO MANY MESH POINTS)
     LERR=1
     RETURN-
     END
```

```
$IBFTC MESHB LIST, DECK, REF, DD, XR7
                    SUBROUTINE MESHB(NODE, A, CENY, CENY, PLEBAK, PLEIN, IX, L2)
                    -COMMON - Zamen - second secon
                    DIMENSION Z(20000), IB(100), NODE(IX,L2), A(IX,L2), CENX(IX,L2),
                 2CENY(IX, L2), PLEBAK(IX, L2), PLEIN(IX, L2), IE(100)
                    EQUIVALENCE (Z(5200), LB), (Z(2), IOUT), (Z(11), LERR),
                2(Z(6116),1B(1)),
                                                                                       (Z(6216), IE(1)), (Z(5400), I), (Z(5401), JP),
                5(Z(5402),AMIN),(Z(5403),RATIO),(Z(5404),J),(Z(5405),IFLAG)
                    IFLAG=0
                  -AMIN=.45E-4-
          12 J=1
      101-K=J-
             2 I = IB(J)
      103-1-F(NODE(1+1-,U)))130-30-130
       130 RATIO= A(I+1,J)/A(I,J)
        126 IF(A(I,J)-AMIN)26,26,403
      403 IF (NODE (I, J)-1) 404, 405, 404
      404 IF(NODE(I,J)-4)3,405,3
      405-IF(NODE(I+1,J)-1)406,26,406
      406 IF(NODE(I+1,J)-4)3,26,3
        -26 IF(I-Ib(J))3,25,3
          25 CENX(I+1,J)=(A(I+1,J)*CENX(I+1,J)+A(I,J)*CENX(I,J))/(A(I+1,J)+A(I,
               -1J))
                    (A(I+1,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,J)+A(I,
                -1·J-)-)--
                     A(I+1,J)=A(I+1,J)+A(I,J)
                    PLEBAK(I+1,J)=PLEBAK(I+1,J)+PLEBAK(I,J)
                     IF(NODE(I+1,J)-1)200,201,200
      200 PLEIN(I+1,J)=PLEIN(I--,J)
                    GO TO 202
      201-PLEIN(I+1,0)=PLEIN(I+1,0)+PLEIN(I,0)
      202 NODE(I+1,J)=NODE(I,J)
                    -NODE(I,J)=-1
                     IB(J) = IB(J) + 1
                   -A (-I • J ) = • O ----
                    CENX(I \rightarrow J) = \bullet O
                    -CENY-(-I-3-J-)-=-0-0---------------------
                    PLEBAK(I,J)=.0 -
                   -PLEIN(I, J) = • 0 ---
                    GO TO 3
        30 IF(NODE(I-1,J))31,131,131
       131 RATIO= A(I-1,J)/A(I,J)
        IF(RAT-I-0-2.) 135.9135.936......
       135 IF(A(I,J)-AMIN)35,3,3
       -31 IF(J-LB)204,203,204-
       203 JP=1
         ---GO-TO-205-
       204 JP=J+1
      205 IF (NODE (I, JP))3,3,206
       206 IF(A(I,J)-AMIN)45,3,3
         36 IF (I-IE(J))3,35,3
          35 CENX(I-1,J)=(A(I,J)*CENX(I,J)+A(I-1,J)*CENX(I-1,J))/(A(I,J)+A(I-1,
                <del>-1J))-</del>
                     CENY(I-1,J)=(A(I,J)*CENY(I,J)+A(I-1,J)*CENY(I-1,J))/(A(I,J)+A(I-1,
                 ---(-ل-1
                     A(I-1,J)=A(I-1,J)+A(I,J)
```

```
PLEBAK(I-1,J)=PLEBAK(I,J)+PLEBAK(I-1,J)
    NODE(I-1,J)=NODE(I,J)
    NODE(I,J)=0
    - I E (・J ) = I E (-J ) -- l --
    A(I,J)=.0
    CENX (I) - 0
    CENY(I,J)=0
    PLEBAK ( I , J ) = . 0 ----
    PLEIN(I,J)=.0
   --GO-TO-3---
 45 CENX(I,J)=(A(I,J)*CENX(I,J)+A(I,JP)*CENX(I,JP))/(A(I,J)+A(I,JP))
    -CENY(I-,J)=(A(I-,J)*CENY(I-,J)+A(I-,JP)*CENY(I-,JP))/(A(I-,J)+A(I-,JP))
    PLEIN(I,J)=PLEIN(I,J)+PLEIN(I,JP)
    A(I,J)=A(I,J)+A(I,JP)
    LB=LB-1
    -DO 305-J=JP,LB-
    I = IB(J)
-304-A(-I-,-J-)-A-(-I-,-J+I-)----
    CENX(I,J) = CENX(I,J+1)
    CENY(I,J)=CENY(I,J+1)
    PLEBAK(I,J)=PLEBAK(I,J+1)
    PLEIN(I,J)=PLEIN(I,J+1)
    IF(I~IE(J))303,305,305
303-I=I+]----
    GO TO 304
305 CONTINUE -
  3 \text{ IF}(I-IE(J))306,1,1
306 I = I + 1
    GO TO 103
--1-1F(J-Lb)308,307,307
308 J=J+1
  ---GO-TO-101---
307 IF(IFLAG-1)310,309,310
310 IFLAG=1 ----
    GO TO 12
309 RETURN
    END
```

```
$IBFTC MESHC LIST, DECK, REF, DD, XR7
      SUBROUTINE MESHC (CONDB, NODE, CONDI, PLEBAK, CENX, CENY, A, T, PLEIN, IX, L2
     Jeer) reason was been an about
      COMMON Z
     DIMENSION Z(20000), CONDB(IX, L2), NODE(IX, L2), IB(100), IE(100),
     1CONDI(IX,L2),PLEBAK(IX,L2),XPNT(100),CENX(IX,L2),CENY(IX,L2),
     <del>2A(IX,</del>L2),T(IX,L2),TTE(100),PLEIN(IX,L2),YPNT(100),ZA(200)
      EQUIVALENCE (Z(2), IOUT), (Z(5200), LB), (Z(11), LERR),
                           (Z(6216), IE(1)), (Z(6116), IB(1)),
     3
                                              (7(11716),XPNT(1)),
    4(Z(11816),YPNT(1)),
     5(Z(4418),TIN),(Z(5206),TC),(Z(5207),TR),(Z(5208),IMAXP),
     6(Z(6016),TTE(1)),(Z(627),ZA(1)),(Z (626),TP),(Z(5400),JX),
     7(Z(5401),YZ),(Z(5402),XZ),
                                          (Z(5404),X1),
     8-----(Z(5408)))JXP)),(Z(5407),JPP),(Z(5408))
     9(Z(5409),JP),(Z(5410),J),(Z(5411),I),(ZA(75),TPR)
      REAL LENGTH
      DO 302 J=1,L2
     DO 301 I=1,IX-
      CONDB(I,J)=.0
     301 CONTINUE
  302-CONTINUE-
      DO 100 J=1,LB
     -JX=J+LB -
    1 I = IB(J)
   .....IF-(......I-)--1-0-2-9-1-0-1-9-2-9-1-0-2-9-
  101 JP=LB
    ---JPX=2*LB--
      GO TO 2
  1-02--JP=J--1---
      JPX=JP+LB
   2 CONTINUE
   11 IF(J-LB)104,103,104
  103-JPP=1---
      JXP=LB+1
     -GO-TO-105-
  104 JPP=J+1
     -JXP=JPP+tb
  105 IF(NODE(I, JPP))106,106,107
  106 CONDB(I,JPP)=.0-
      CONDB(I,JXP)=CONDB(I,JPP)
  107 IF(NODE(I,JP))108,108,7
  108 CONDB(I,J)=.0
    9 IF(NODE(I+1,J))10,109,10
  109-CONDI(I+1,J)=.0-
      CONDI(I+1,JX)=0
      -GO--TO--10-----
    7 X2=CENX(I,JP)
     -Y-2=CENY-(-I-,-JP)-
      XI = CENX(I,J)
      -Y-1=CENY-(-I-,-J-)--
      XLENTH=LENGTH(X1,Y1,X2,Y2)
      CONDE(I,J) = (TP*PLEBAK(I,J))/XLENTH-
      CONDB(I,JX)=CONDB(I,J)*TPR/TP
      GO 70-9-
   10 IF(I-IB(J))25,4,25
```

```
4 X1=XPNT(J)
   Y1=YPNT(J)
    GO TO 5
 25 X1=CENX(1-1,J)
    Y1 = CENY(I-1,J)
  5-X2=CENX(I,J)-----
    Y2=CENY(I,J)
    XLENTH=LENGTH(X1,Y1,X2,Y2)
    CONDI(I,J)=(TP*PLEIN(I,J))/XLENTH
    CONDI(-I, JX-) = CONDI(I, J) * TPR/TP
  6 A(I,JX) = A(I,J)
    -T-(-I-, J-)=T-I-N---
    T(I,JX) = TIN
 16-IF(I-IE(J))112,111,111
112 I = I + 1
  ---GO TO 2--
111 IB(JX) = IB(J)
    -I E (・JX・) = I E (・J・)
100 CONTINUE
  ---TC=TIN---
    TR=TIN
    DO 200 I = 2 , IMAXP
200 TTE(I)=TIN
    -RETURN-
    END
```

```
SIBFTC AREA
                LIST, DECK, REF, DD, XR7
      SUBROUTINE AREA (XA, XB, XC, YA, YB, YC, A, CA, CB)
      DIMENSION XZ(4),YZ(4)
      DIMENSION Z(20000), XP(3), C(4)
                                                                                  ΑF
      EQUIVALENCE (Z(2), IOUT)
      EQUIVALENCE (2(5300), M), (2(5301), J), (2(5302), C(1)), (2(5306), XP(1))
                                                                                  AF
                                                                                  AF
     2,(Z(5309),K),(Z(5310),I),(Z(5311),CT),(Z(5312),BT),(Z(5313),AT),
     3(Z(5314),F),(Z(5315),E),(Z(5316),G),(Z(5317),D),(Z(5318),TBAR),
                                                                                  16
                                                                                  AF
     4(Z(5319),SBAR),(Z(5320),T),(Z(5321),S2),(Z(5322),S1),(Z(5323),COSA
                                                                                  AF
     5),(Z(5324),S),(Z(5325),ZA),(Z(5326),Y),(Z(5327),X)
                                                                                  AF
      COMMON Z
      LOGICAL AA, AB, AC
      REAL LENGTH
      IOUT=6
COMPUTE LINE LENGTHS
      ZA=LENGTH(XA,YA,XB,YB)
      Y=LENGTH(XA,YA,XC,YC)
      Y = LENGTH(XB, YB, XC, YC)
                                                                                  Al
      S=(X+Y+ZA)/2
                                                                                  Αſ
COMPUTE AREA
                                                                                  Al
      A=SQRT(S*(S-X)*(S-Y)*(S-ZA))
                                                                                  Af
COMPUTE CENTROID IF REQUIRED
      GO TO 2
    1 CONTINUE
  101 FORMAT(1H ,6E15.6)
  102 FORMAT (1H ,416)
  201 CONTINUE
      RETURN
    2 COSA=(Y*Y+ZA*ZA-X*X)/(2.*Y*ZA)
                                                                                  ΑI
      COSC=(X*X+Y*Y-ZA*ZA)/(2.*X*Y)
       IF(COSA)103,103,104
  104 IF(COSC)106,106,105
  103 S1 = -ZA*COSA
      S2=Y
       T=ZA*SQRT(ABS(1.-COSA*COSA))
      CF = S2/(S1 + S2)
       SBAR=((S2-S1)/3.)*CF
       51=0
       GO TO 108
  106 S1=Y
       S2=-X*COSC
       T=X*SQRT(ABS(1.-COSC*COSC))
     · CF=S1/(S1+S2)
       SBAR=((S2-S1)/3.)*CF
       S2=.0
       GO TO 108
  105 S1=ZA*COSA
       S2=Y-S1
       T=ZA*SQRT(ABS(1.-COSA*COSA))
       CF=1.
       SBAR=((S2-S1)/3.)*CF
  108 TBAR=(T/3.
                     ) *CF
       D=(S1+SBAR)**2+TBAR**2
       G=(S2-SBAR)**2+TBAR**2
       IF(ABS(XA-XC)-1.E-5)110,110,109
   110 IF(YA-YC)111,121,111
   111 C(1) = (YA * YA - YC * YC - D + G) / (2 * (YA - YC))
       C(2)=C(1)
       BT=-2.*XA
       CT=XA*XA+YA*YA-2.*YA*C(1)+C(1)*C(1)-D
       AT=1.
```

```
CA=BT*BT-4.*AT*CT
      IF(CA)3,112,112
  112 CA=SQRT(ABS(CA))
      C(3) = (CA - BT)/2
      C(4) = (-BT - CA)/2
      GO TO 21
  109 E=(D-G-XA*XA+XC*XC-YA*YA+YC*YC)/(2.*(XC-XA))
      F = (YA - YC) / (XC - XA)
                                                                                     AF
      AT=F*F+1.
                                                                                     Αſ
      BT=2.*(F*E-XA*F-YA)
                                                                                     AF
      CT=XA*XA-2.*XA*E+E*E+YA*YA-D
                                                                                     AF
      CA=BT*BT-4.*AT*CT
      IF(CA)3,4,4
    3 WRITE (IOUT,5)
    5 FORMAT (44HOIMAGINARY NUMBER FAILURE IN SUBROUTINE AREA)
                                                                                     Al
   18 GO TO 1
    4 CA=SQRT(ABS(CA))
      CB=(CA-BT)/2./AT
                                                                                     Al
      CT = (-BT - CA)/2 \cdot /AT
                                                                                     Al
CHECK FOR BEHAVIOR OF VALUE - IT MUST BE IN RANGE OF POINTS
                                                                                     A
      I = 1
                                                                                     A
      K=1
                                                                                     A
      XP(1)=YA
                                                                                     A:
      XP(2)=YB
                                                                                     Α
                                                                                     Α
      XP(3)=YC
      C(1) = CB
      C(2)=CT
   14 CONTINUE
    7 IF(C(I)-XP(1))8,9,10
      IF(C(I)-XP(2))11,9,9
   10 IF(C(I)-XP(2))9,9,12
                                                                                     Α
   11 \text{ IF}(C(1)-XP(3))13,9,9
   12 IF(C(I)-XP(3))9,9,13
                                                                                     A
   13 GO TO (15,16,26,28),K
   15 J=0
      K=2
      I = 2
      GO TO 14
   16 IF(J)20,121,20
  121 WRITE(IOUT, 17)
   17 FORMAT(41HOCENTROID TEST FAILURE IN SUBROUTINE AREA)
      GO TO 18
    9 GO TO (19,22,27,31),K
   19 K=2
      I = 2
      J=1
      GO TO 14
   22 IF(J)23,24,23
   23 J=-1
      GO TO 20
   24 J=2
   20 I=3
      XP(1)=XA
      XP(2)=XB
      XP(3)=XC
      K=3
      C(3) = E + F * C(1)
      C(4) = E + F * C(2)
      GO TO 14
   26 K=4
      M÷Q
```

```
I = 4
    GO TO 14
                                                                              Α
27 K=4
                                                                              Α
    I = 4
                                                                              Α
   M=1
    GO TO 14
28 IF(M)29,121,29
31 IF(M)32,33,32
                                                                              Α
32 M=-1
                                                                              Α
    GO TO 29
33 M=2
29 IF(M)62,121,63
62 IF(J)21,121,65
63 IF(J)65,121,64
64 IF(M-J)121,66,121
65 IF(J)66,121,35
66 CA = C(M+2)
    CB=C(M)
    GO TO 201
 35 CA=C(J+2)
    CB=C(J)
    GO TO 201
21 XZ(1)=XB
    YZ(1) = YB
    XZ(2)=XC
    YZ(2)=YC
    XZ(3)=XA
    YZ(3)=YA
    XZ(4) = C(3)
    YZ(4)=C(1)
    CALL INTER(XZ,YZ,XPP,YP)
    NN=1
    CY=C(1)
    CX = C(3)
151 FORMAT(1H ,4E15.6)
122 AA=XPP.GE.XB
    AB=XPP.LE.XC
    AC=AA.AND.AB
    IF(AC) GO TO 126
    XX=XPP-XB
    XXXX=XPP-XC
124 IF((XPP.LE.XB).AND.(XPP.GE.XC)) GO TO 126
    IF(ABS(XPP-XB)-1.E-6)205,205,125
205 IF (ABS(XPP-XC)-1.E-6)126,126,125
125 GO TO (140,141),NN
126 IF((YP.GE.YB).AND.(YP.LE.YC)) GO TO 128
127 IF((YP.LE.YB).AND.(YP.GE.YC)) GO TO 128
    IF(ABS(YP-YB)-1.E-6)206,206,125
206 IF(ABS(YP-YC)-1.E-6)128,128,125
128 IF((CX.GE.XA).AND.(CX.LE.XPP)) GO TO 131
130 IF((CX.LE.XA).AND.(CX.GE.XPP)) GO TO 131
    GO TO 125
131 IF((CY.GE.YA).AND.(CY.LE.YP)) GO TO 133
132 IF((CY.LE.YA).AND.(CY.GE.YP)) GO TO 133
    GO TO 125
133 GO TO (142,143),NN
140 J=0
135: NN=2
    XZ(4)=C(4)
    YZ(4)=C(2)
    CALL INTER(XZ,YZ,XPP,YP)
```

CX = C(4)CY=C(2) GO TO 122 141 IF(J)121,121,134 134 CA=C(3) CB=C(1) GO TO 201 142 J=1 GO TO 135 143 IF(J-1)136,121,136 136 CA=C(4) CB=C(2) GO TO 201 END A

```
-SIBFTC LENGTH LIST, DECK, DD, XR7---
                                                                                -LE
       REAL FUNCTION LENGTH (XA, YA, XB, YB)
                                                                                 LE
       LENGTH-SQRT((XB-XA)**2+(YB-YA)**2)
                                                                                LE
       RETURN
                                                                                 LE
      -END-----
                                                                                 ĿΕ
SIBFTC INTER
                LIST, REF, DD, XR7
      -SUBROUTINE INTER (X,Y,XA,YA)
       DIMENSION X(4), Y(4), Z(20000)
      EQUIVALENCE (Z(2), IOUT)
      -IF(X(1)-X(2))10,11,10-
   11 IF (X(3)-X(4)) 10,4,10
   10 IF(Y(1)-Y(2))19291
    2 \text{ IF}(Y(3)-Y(4))3,4,3
    4-WRITE (IOUT,5)
     5 FORMAT (17HOFAILURE IN INTER)
     -- CALL EXIT-
    3 YA=Y(1)
     ---XA=(X(4)*Y(3)-X(3)*Y(4)-(X(4)-X(3)-)*Y(1-)-1/(Y(3)-Y(4-)-
    6 RETURN
    8 YA=Y(3)
     ~XA=(X(2)*Y<del>(1)~X(1)*Y(2)~(X(2)~X(1))*Y(3)~//(1)~//(1)~Y(-2)</del>~
       GO TO 6
    ~7~YA={(X{4}*Y{3}<del>~X{3}*Y{4}</del>)}<del>/Y{43}~Y{4}}}~X</del>
      2-Y(2))/((X(4)-X(3))/(Y(3)-Y(4))-(X(2)-X(1))/(Y(1)-Y(2)))
      ~XA=-{-X-{-2-}-*Y-{-1-}->--X-(-1-)-*Y-(-2-)---(-X-(-2-)---X-(-1-)-)-*Y-A-)-/-(-1-)---Y-(-1-)---Y-(-2-)---
       GO TO 6
      -END----
SIBFTC POINT
                LIST, DECK, DD, XR7
      -SUBROUTINE POINT (R.T. X.Y.B)
       COMMON Z
       DIMENSION Z (20000)
       EQUIVALENCE (Z(5345),U),(Z(5344),V),(Z(5343),TEMP),(Z(5342),TEMPD) PO
      2, (Z(5341), TEMPE), (Z(5340), TEMPA)
       IF(B)3,1,2
     1 U=(R+T)/2.
     4 RETURN
    3-V=(R+T)/2.
      TEMP=ATAN(V/U)
       TEMPD=COS/TEMP)
       TEMPE=SIN(TEMP.)
       GO-TO-4-
     2 TEMP=COS(T)
       TEMPASIN(T)
       X=-R*(TEMP*TEMPD-TEMPA*TEMPE)+U.
       Y=-R*(TEMPA*TEMPD+TEMP*TEMPE)+V-
       GO TO 4
       END
```

```
SUBROUTINE PROP(T, V1, V2, V3, V4, V5, V6, MAY)
    COMMON Z
    DIMENSION Z(20000), I(17), IXB(20), IXE(20)
    EQUIVALENCE (Z(17416), IXB(1)), (Z(17436), IXE(1))
    DATA I(1), I(2), I(3), I(4), I(5), I(6), I(7), I(8), I(9), I(10), I(11), I(12)
   22/
    IF(MAY-6)17,17,50
 50 IF(MAY-12)37,37,51
 51 IF(MAY-16)7,7,52
 52 IF(MAY-17)53,27,53
 53 WRITE(IOUT,54)
 54 FORMAT(13HO TABLE ERROR)
    LERR=1
    RETURN
  7 IF(IXB(MAY)-IXE(MAY))407,400,400
400 IXX=IXB(MAY)+1
    V1=Z(IXX+2644)
    V2=Z(IXX+3044)
    V3=Z(IXX+2444)
    V4=Z(IXX+3444)
    V5=Z(IXX+212)
    RETURN
407 IXX=IXB(MAY)-1+ I(MAY)
1006 IF(IXX-IXE(MAY))2001,2001,2002
2002 IXX=IXX-1
    GO TO 1006 -
2001 IF(IXX-IXB(MAY)-1)2003,6,6
2003 IXX=IXX+1
    GO TO 2001
   6 IF(T - Z(IXX+413))1003,2004,1
2004 IXX=IXX+1
  2 A=0.0
    GO TO 8
   1 IXX = IXX + 1
     IF(IXX-IXE(MAY))1006,55,55
 55 IXX = IXE(MAY) + 1
     GO TO 2
1003 IF(IXX-IXE(MAY))2011,2011,2012
2012 IXX=IXX-1
     GO TO 1003
2011 IF(IXX-IXB(MAY)-1)2013,3,3
2013 IXX=IXX+1
     GO TO 2011
   3 \text{ IF}(T - Z(IXX+413))4, 2,5
   4 IXX=IXX-1
     IF(IXX-IXB(MAY))57,57,1006
  57 IXX=IXB(MAY)+1
     GO TO 2
   5 A = (T - Z(IXX + 412))/(Z(IXX + 413) - Z(IXX + 412))
   8 V1=Z(IXX+2644) + A*(Z(IXX+2645)-Z(IXX+2644))
     V2=Z(IXX+3044) + A*(Z(IXX+3045)-Z(IXX+3044))
     V3=Z(IXX+2444) + A*(Z(IXX+2445)-Z(IXX+2444))
     V4=Z(IXX+3444) + A*(Z(IXX+3445)-Z(IXX+3444))
     V5=Z(IXX+212) + A*(Z(IXX+213)-Z(IXX+212))
     I(MAY) = IXX + 1 - IXB(MAY)
     RETURN
  17 IF(IXB(MAY)-IXE(MAY))417,401,401
 401 IXX = IXB(MAY) + 1
     V1=Z(1XX+1031)
     V2=Z(IXX+1231)
```

```
V3=Z(IXX+1431)
     V4=Z(IXX+1631)
     V5=Z(IXX+2031)
     RETURN
417 IXX=IXB(MAY)-1 + I (MAY)
1016 IF(IXX-IXE(MAY))2014,2014,2015
2015 IXX=IXX-1
     GO TO 1016
2014 IF(IXX-IXB(MAY)-1)2016,16,16
2016 IXX=IXX+1
     GO TO 2014
  16 \text{ IF}(T - Z(IXX+832))1013,2017,11
2017 IXX=IXX+1
  12 A=0.0
     GO TO 18
  11^{\circ}IXX=IXX+1
     IF(IXX-IXE(MAY))1016,155,155
 155 \text{ IXX} = \text{IXE}(\text{MAY}) + 1
     GO TO 12
1013 IF(IXX-IXE(MAY))2018,2018,2019
2019 IXX=IXX-1
     GO TO 1013
2018 IF(IXX-IXB(MAY)-1)2020,13,13
2020 IXX=IXX+1
     GO TO 2018
  13 IF(T-Z(IXX+831 ))14, 12,15
  14 IXX = IXX - 1
     IF(IXX-IXB(MAY))157,157,1016
 157 IXX=IXB(MAY) +1
     GO TO 12
  15 A = (T - Z(IXX + 831)) / (Z(IXX + 832) - Z(IXX + 831))
  18 V1 = Z(IXX+1031) +A*(Z(IXX+1032) -Z(IXX+1031))
     V2 = Z(IXX+1231) +A*(Z(IXX+1232) -Z(IXX+1231))
     V3 = Z(IXX+1431) +A*(Z(IXX+1432) -Z(IXX+1431))
     V4 = Z(IXX+1631) +A*(Z(IXX+1632) -Z(IXX+1631))
     V5 = Z(IXX + 2031) + A*(Z(IXX + 2032) - Z(IXX + 2031))
     I(MAY) = IXX + 1 - IXB(MAY)
     RETURN
  37 IF(IXB(MAY)-IXE(MAY))437,402,402
 402 IXX=IXB(MAY)+1
     V3=Z(IXX+12)
     RETURN
 437 IXX=IXB(MAY)-1+I(MAY)
1036 IF(IXX-IXE(MAY))2023,2023,2022
2022 IXX=IXX-1
     GO TO 1036
2023 IF(IXX-IXB(MAY)-1)2024,36,36
2024 IXX=IXX+1
     GO TO 2023
  36 IF(T-Z(IXX+413))1033,2021,31
2021 IXX=IXX+1
  32 A= 0
     GO TO 38
  31 IXX = IXX + 1
     IF(IXX-IXE(MAY))1036,355,355
 355 IXX=1XE(MAY) +1
     GO TO 32
1033 IF(IXX-IXE(MAY))2025,2025,2026
2026 IXX=IXX-1
     GO TO 1033
2025 IF(IXX IXB(MAY)-1)2027,33,33
```

```
2027 IXX=IXX+1
     GO TO 2025
  33 IF(T-Z(IXX+412))34, 32,35
  34 IXX = IXX - 1
      IF(IXX-IXB(MAY))357,357,1036
 357 IXX=IXB(MAY)+1
     GO TO 32
  35 A=(T-Z(IXX+412))/(Z(IXX+413)-Z(IXX+412))
  38 V3=Z(IXX+12) +A*(Z(IXX+13)-Z(IXX+12))
      I(MAY) = IXX + 1 - IXB(MAY).
     RETURN
  27 IF (IXB (MAY) - IXE (MAY)) 427,403,403
 403 IXX=IXB(MAY)+1
      V1=Z(IXX+3754)
     V2=Z(IXX+3854)
     V3=Z(IXX+3954)
      V4=Z(IXX+4054)
     V5 = Z(IXX + 4154)
      V6=Z(IXX+4254)
     RETURN
 427 IXX=IXB(MAY)-1 + I(MAY)
1026 IF(IXX-IXE(MAY))2028,2028,2029
2029 IXX=IXX-1
      GO TO 1026
2028 IF(IXX-IXB(MAY)-1)2030,26,26
2030 IXX=IXX+1
      GO TO 2028
  26 IF(T- Z(IXX+3655))1023,2031,21
2031 IXX=IXX+1
  22 A=0.0
      GO TO 28
  21 IXX = IXX + 1
      IF(IXX-IXE(MAY))1026,255,255
 255 IXX = IXE(MAY) + 1
      GO TO 22
1023 IF(IXX-IXE(MAY))2032,2032,2033
2033 IXX=IXX-1
      GO TO 1023
2032 IF(IXX-IXB(MAY)-1)2034,23,23
2034 IXX=IXX+1
      GO TO 2032
  23 IF(T- Z(IXX+3654)) 24, 22,25
  24 IXX = IXX-1
      IF(IXX -IXB(MAY))257,257,1026
 257 IXX = IXB(MAY) +1
      GO TO 22
  25 A=(T-Z(IXX+3654))/(Z(IXX+3655)-Z(IXX+3654))
   28 V1=Z(IXX+3754) + A*(Z(IXX+3755)- Z(IXX+3754))
      V2=Z(IXX+3854) + A*(Z(IXX+3855)- Z(IXX+3854))
      V3=Z(IXX+3954) + A*(Z(IXX+3955)- Z(IXX+3954))
      V4=Z(IXX+4054) + A*(Z(IXX+4055)- Z(IXX+4054))
      V5=Z(IXX+4154) + A*(Z(IXX+4155)- Z(IXX+4154))
      V6=Z(IXX+4254) + A*(Z(IXX+4255) - Z(IXX+4254))
      I(MAY) = IXX+1-IXB(MAY)
      RETURN
      END
SORIGIN
               ETA
```

```
SIBFTC CALCS
               DECK . XR7
      SUBROUTINE CALCS(XK,CAP,EPSC1,EPSC2,EPSR1,EPSR2,ALPH,T,A,T4,
     1CONDI, CONDB, TERMF, TERMO, IX, L2,
      COMMON Z
      DIMENSION Z(20000), XK(IX, L2), XKTE( 100 ), CAP(IX, L2), CAPTE( 100 ),
     1ALPHA(100), RESIST(100), EPSC1(IX , L22), EPSC2(IX , L22), EPSR1(IX , L22)
     2), EPSR2(IX , L22), ALPH(IX, L2), EPSI(100), T(IX, L2), TTE(100), A(IX, L2),
     3T4(IX,L2),CONDI(IX,L2),CONDB(IX,L2),TERMF(IX,L2),TERMO(IX,L2),
     4TP(100), IB(100), IE(100), ZA(200), TMPTR(1000), TPRE(1000),
     5WRIT(10,12) ,MATTE(15)
      EQUIVALENCE (Z(2), IOUT), (Z(5200), LB), (Z(11), LERR),
     1(Z(11716),XKTE(1)),(Z(5916),EPSI(1)),(Z(6016),TTE(1)),
     2(Z(11816),CAPTE(1)),(Z(5716),ALPHA(1)),(Z(5816),RESIST(1)),
     3(Z(17316), TP(1)) , (Z(4414), TMACH) , (Z(3246), WRIT(1)) ,
     4(ZA(54), XMAT)
                       ,(Z(4415),MATC),(Z(4416),MATR)
      EQUIVALENCE (Z (6116), IB(1)), (Z (6216), IE(1)),
     1(Z(627),ZA(1)),(ZA(4),UO),(ZA(5),VO),(ZA(6),U),(ZA(7),V),
     2(Z (4356), SOLC), (Z (4357), ALBE), (Z (4358), SIGMA),
     3(Z (4400), RE), (Z(5208), IMAXP), (Z ( 626), TPLC),
     4(Z(5467), TPLAN), (Z(5466), F1C), (Z(5465), F1R), (Z(5464), F2C),
     5(Z(5463),F2R),(Z(5468),DELTA),(Z(5206),TC),(Z(5207),TR),
     6(Z(5462),ALPHAC),(Z(5461),EPSC),(Z(5469),TCP),(Z(5460),CAPC),
     7(Z(5459),DELTMP),(Z(5470),TRP),(Z(5458),F3),(Z(5457),F1),
     8(Z(5456),F2),(Z(4411),EPST),(Z(4402),TIMAX),(Z(4412),NL),
     9(Z(4413), NS),(Z(4419),CFACT),(Z(5455),NTT),(Z(5454),NITMAX)
      EQUIVALENCE
                                    (Z(5452), TAVC4), (Z(5451), EPSAR),
     1(Z(5450), TAVR4), (Z(5449), EPSAC), (Z(5448), RI), (Z(5447), E),
     2(Z(5446), VOLT), (Z(5445), CURRNT), (Z(5444), POWR), (Z(4410), ISS),
     3(Z(5442),TI4),(Z(5441),TCP4),(Z(5440),CCR),(Z(5439),RCR),
     4(Z(5438),TIME),(Z(5437),TIML),(Z(5436),TIMS),(Z(4406),TIMPL),
     5(Z(4407), TIMPS), (Z(4405), TIMF), (Z(5480), TERM3),
     6(Z(5435),V1),(Z(5434),V2),(Z(5433),V3),(Z(5432),V4),
     7(Z(5431),V5),(Z(5430),V6),(Z(5429),MAY),(Z(5428),J),
     8(Z(5427),TXX),(Z(5426),I),(Z(5425),JL),(Z(5424),JU),
     9(ZA(75), TPLR)
      EQUIVALENCE (Z(5423), TERM2), (Z(5422), TERM6), (Z(5421), TERMR),
     1(Z(5420),EA),(Z(5419),ATOT),(Z(5418),AXT),(Z(5417),JJ),
     2(Z(5416),II),(Z(5478),LP),
                                                   (Z(5414),TERM4),
     3(Z(5413),TERM5),(Z(5412),TERM7),(Z(5411),Q),(Z(5410),TERM1),
     4(Z(5409), LBJ), (Z(5408), IC), (Z(5407), JF), (Z(5473), TEPL),
     5(Z(5476), EPSP), (Z(5406), LONG), (Z(5474), NLINE), (Z(14616), TMPTR(1))
     6,(Z(5405),LL),(Z(5404),LU),(Z(5403),IA),
     7(Z(5472), LMAX), (Z(5471), TPR), (Z(5401), JZ), (Z(5400), JY),
     8 (Z(4403), TMIN), (Z(4404), TMX), (Z(4401), SEGM),
     9(Z(5211), DELX), (ZA(166), XIMAX), (Z(18000), TPRE(1))
      DO 7900 IN=1,10
      DO 7900 JN=1,12
 7900 WRIT(IN, JN)=0.
      QO2=0.
      NITMAX=TMX
       TMULT=TIMF
       TDEC=TMULT/100.
      SLB=LB
      LBNEW=SLB/SEGM+.01
       JJZ=1
      DO 7501 I=1,4
       IF(LBNEW-JJZ)7501,7502,7501
 7501 プリスキ2★プリスト、大学に対しまり、日本学に対するで、神話
```

```
LBNEW=1
7502 WJZ=LBNEW
     NOSEG=LB/LBNEW
     IF(NOSEG-LB)7503,7504,7504
7503 IL=IB(1)
     IU=IE(1)
     DO 7505 I=IL, IU
     CONDB(1,1)=0.
7505 CONDB(I,LB+1)=0.
     IL=IB(NOSEG+1)
     J=LB+NOSEG+1
     IU=IE(J)
     DO 7506 I=IL, IU
     CONDB(I,NOSEG+1)=0.
7506 CONDB(I,J)=0.
7504 CONTINUE
     TIMF=0.
     JFLAG=0
     NLINE=0
     JCNT=TMACH
     IMAX=XIMAX
     KX=0
     NIT=0
     DELT=1.0
  25 TERM3=SOLC*ALBE
     TIMS = TIMPS
                                                                              PRNT
     TIML = TIMPL
     DELTM=10.
 607 NIT=NIT+1
     TIME=0.
     IF(NIT-100)7010,7011,7011
7010 TIMF=TIMF+TDEC
7011 JTE=XMAT
     JCOL=MATC
     JRAD=MATR
     JCCON=ZA(79)+1.E-4
     JRCON=ZA(119)+1.E-4
     CALL PROPITC, V1, CAPC, ALPHAC, EPSC, EPS2C, V6, JCOL)
     CALL PROP(TR, V1, CAPR, ALPHAR, EPSR, EPS2R, V6, JRAD)
     DO 600 J=1,NOSEG
      I = IB(J)
 603 TXX = T(I_9J)
     CALL PROP ( TXX, V1, V2, V3, V4, V5, V6, JCOL)
     XK(I_9J) = V1
     CAP(I,J)=V2
     ALPH(I,J)=V3
     EPSC1(I_9J)=V4
     EPSC2(I_9J)=V5
     IF(I-IE(J))601,600,600
 601 I = I+1
     GO TO 603
 600 CONTINUE
     JL= LB+1
     JU=NOSEG+LB
     DO 602 J=JL,JU
     I=IB(J)
 605.TXX = T(I_9J)
     CALL PROP(TXX,V1,V2,V3,V4,V5,V6,JRAD)
     XK(I_9J) = V1
     CAP(I_9J)=V2
     ALPH(1,J)=V3
```

```
EPSR1(I,J)=V4
            EPSR2(I,J)=V5
            IF(I-IE(J))604,602,602
604 I=I+1
            GO TO 605
602 CONTINUE
            DO 606 I=2, IMAXP
            TXX=TTE(I)
            CALL PROP(TXX,V1,V2,V3,V4,V5,V6,JTE)
            ALPHA(I)=VI
            XKTE(I) = V2
            RESIST(I)=V3
            CAPTE(I )=V4
            EPSI(I)
                                       =V5
606 CONTINUE
            MAY=17
            CALL PROP(TIME, TPLAN, F1C, F1R, F2C, F2R, DELTA, MAY)
            DELTA=DELTA/57.296
            CALL PROP(TC, V1, V2, CCR, V4, V5, V6, JCCON)
            CALL PROP(TR, VI, V2, RCR, V4, V5, V6, JRCON)
            TERM2=SIGMA*TPLAN*TPLAN*TPLAN*TPLAN
             IF(DELTA-1.5708)810,810,811
810 TERMC=SOLC*COS(DELTA)
             TERMR= . O
            GOTO 812
811 TTHMR=SOLC*COS(DELTA)
             YERMC= . O
87 CONTINUE
   21 EA=.0
            EPSAR= 0
            TAVR4=.0
            ATOT = 0
            0.0 = TXA
            JJ=LB+1
   11 II = IB(JJ)
   12 ATOT=ATOT+A(II,JJ)
            (LL, II) T*(LL, II) T*(LL, II) T*(LL, II) T=(LL, II) T=(LL, II) +T
            AXT = AXT + A(II, JJ) * T4(II, JJ)
            EA=EA+A(II,JJ)*EPSR2(II,JJ)
             IF(II-IE(JJ))101,100,100
101 II=II+1
            GO TO 12
100 LP=LB+NOSEG
             IF(JJ-LP)103,102,102
103 JJ=JJ+1
             GO TO 11
102 TAVR4=AXT/ATOT
            EPSAR=EA/ATOT
             TAVR=SQRT(TAVR4)
             TAVR=SQRT(TAVR)
   20 EA= 0
             TAVC4= . 0
            ATOT= .0
            O. = TXA
             EPSAC= . 0
            JJ=1
    13 II = IB(JJ)
    14 ATOT=ATOT+A(II,JJ)
             (LL, II) T*(LL, II) T*(LL, II) T*(LL, II) T=(LL, II) T+(LL, II) T
             AXT=AXT + A(II,JJ)*T4(II,JJ)
             EA=EA+A(II,JJ)*EPSC2(II,JJ)
```

```
IF(II-IE(JJ))108,109,109
108 II=II+1
    GO TO 14
109 IF(JJ-NOSEG)110,111,111
110 JJ=JJ+1
    GO TO 13
111 TAVC4=AXT/ATOT
    EPSAC=EA/ATOT
    TAVC=SQRT(TAVC4)
    TAVC=SQRT(TAVC)
                       ALPHA(2)
    E=(TTE(2)-TR)*
    DO 380 I=3, IMAXP
380 E=E+(TTE(I)-TTE(I-1))*.5*(ALPHA(I)+ALPHA(I-1))
    E=E+(TC-TTE(IMAXP))*
                                   ALPHA(IMAXP)
    DO 381 I=2, IMAXP
381 RI=RI+DELX*RESIST(I)
     RI=1./((U-U0)*(V-V0))*(RI)+RCR+CCR
     CURRNT=E/(RI+RE)
     VOLT=CURRNT*RE
     POWR=VOLT*CURRNT
     GO TO 802
7042 DELTM= . 9*TIMF/DTMAX
     TC=TPRE(1)+DELTM*(TC-TPRE(1))
     TR=TPRE(2) +DELTM*(TR-TPRE(2))
     LI=2
     DO 5019 I=2, IMAXP
     LI=LI+1
5019 TTE(I)=TPRE(LI) +DELTM*(TTE(I)-TPRE(LI))
     LL=1
     LU=NOSEG
     DO 5020 J= LL,LU
     IL=IB(J)
     IU=IE(J)
     DO 5021 I=IL,IU
     LI=LI+1
                       +DELTM*(T(I,J)-TPRE(LI))
5021 T(I,J)=TPRE(LI)
5020 CONTINUE
     LL=LB+1
     LU=LB+NOSEG
     DO 5022 J=LL,LU
     IL=IB(J)
     IU=IE(J)
     DO 5023 I=IL, IU
     LI=LI+l
5023 T(I,J)=TPRE(LI) +DELTM*(T(I,J)-TPRE(LI))
5022 CONTINUE
     GO TO 2074
 366 IF (NIT - NITMAX)607,367,367
 367 CONTINUE
     JFLAG=1
     LONG=1
2001 QIC=0.
     QRC=0.
     QIR=0.
     QRR=0.
     QOC=0.
     QOR = 0 .
     QINC=TERMC*ALPHAC*(U-UO)*(V-VO)+TERM3*F2C*ALPHAC*(U-UO)*(V-VO)
     1+TERM2*F1C*(U-U0)*(V-V0)*EPSC
     QRAC=SIGMA*EPSC*TC**4*(U-UO)*(V-VO)
```

```
QIN=QINC
7901 QOUT=QRAC
7902 GINR=TERMR*ALPHAR*(U-UO)*(V-VO)+TERM3*F2R*ALPHAR*(U-UO)
    1*(V-VO)+TERM2*F1R*(U-UO)*(V-VO)*EPSR
     QRAR=SIGMA*EPSR*TR**4*(U-UO)*(V-VO)
     QIN=QIN+QINR
7904 QOUT=QOUT+QRAR
     DO 7909 J=1,NOSEG
     IL=IB(J)
     IU=IE(J)
     DO 7910 I=IL, IU
     QIC=QIC+TERMC*A(I,J)*ALPH(I,J)+TERM3*A(I,J)*F2C*ALPH(I,J)
    1+TERM2*A(I,J)*F1C*EPSC1(I,J)
     QX=SIGMA*A(I,J)*EPSC1(I,J)*T(I,J)**4
7912 QRC=QRC+QX
     QOC=QOC+QX
7910 CONTINUE
7909 CONTINUE
     QIC=QIC*WJZ
     QRC=QRC*WJZ
     QOC=QOC*WJZ
     QIN=QIN+QIC
     QINC=QINC+QIC
     QRAC=QRAC+QRC
     QOUT=QOUT+QOC
     LL=LB+1
     LU=LB+NOSEG
     DO 7913 J=LL,LU.
     IL=IB(J)
     IU=IE(J)
     DO 7914 I=IL, IU
     QIR=QIR+TERMR*A(I,J)*ALPH(I,J)+ALPH(I,J)*TERM3*A(I,J)*F2R
    1 +TERM2*A(I,J)*F1R*EPSR1(I,J)
     QY=SIGMA*A(I,J)*EPSR1(I,J)*T(I,J)**4
7916 QOR=QOR+QY
     QRR = QRR + QY
7914 CONTINUE
7913 CONTINUE
     QOR=QOR*WJZ
     QRR=QRR*WJZ
     QIR=QIR*WJZ
     QIN=QIN+QIR
     QINR=QINR+QIR
     QRAR=QRAR+QRR
     QOUT=QOUT+QOR
     QAVG= . 5 * (QIN+QOUT+POWR)
                 (QIN-(QOUT+POWR))/QAVG
     ERROR=
     EFF=100.*(POWR/QINC)
     KX = KX + 1
8300 WRIT (KX, 1) = TIME
     WRIT(KX,2)=DELT
     WRIT(KX,3)=NIT
     WRIT(KX,4)=POWR
     WRIT(KX,5)=CURRNT
     WRIT(KX,6)=ERROR
     WRIT(KX,7)=EFF
     WRIT(KX,8)=TC
     WRIT(KX,9)=TR
     WRIT(KX,10)=TAVR
     WRIT(KX,11)=TAVC
     IF(KX-10)8318,8301,8301
```

```
8318 IF(JFLAG)8302,8302,8301
8301 WRITE(IOUT, 8303) (WRIT(KX, 1), KX=1, 10)
8303 FORMAT(1H0,1X,4HTIME,12X,10F11.4)
     WRITE(IOUT, 8305) (WRIT(KX, 2), KX=1, 10)
8305 FORMAT(1H ,1X,14HTIME INCREMENT,2X,10F11.6)
     WRITE(IOUT, 8306) (WRIT(KX, 3), KX=1, 10)
8306 FORMAT(1H ,1X,13HITERATION NO.,3X,10F11.1)
     WRITE(IOUT, 8307) (WRIT(KX, 4), KX=1,10)
8307 FORMAT(1H ,1X,5HPOWER,11X,10F11.5)
     WRITE(IOUT, 8308) (WRIT(KX, 5), KX=1, 10)
8308 FORMAT(1H ,1X,7HCURRENT,9X,10F11.5)
     WRITE(IOUT, 8309) (WRIT(KX, 6), KX=1, 10)
     FORMAT(1H ,1X,5HERROR,11X,10F11.6)
8309
     WRITE(IOUT, 8310) (WRIT(KX, 7), KX=1, 10)
8310 FORMAT(1H ,1X,10HEFFICIENCY,6X,10F11.6)
     WRITE(IOUT,8312)
     WRITE(IOUT, 8311) (WRIT(KX, 8), KX=1, 10)
8312 FORMAT(1H ,1X,12HTEMPERATURES)
8311 FORMAT(1H ,2X,12HHOT JUNCTION,3X,10F11.4)
     WRITE(IOUT, 8313) (WRIT(KX, 9), KX=1, 10)
8313 FORMAT(1H ,2X,13HCOLD JUNCTION,2X,10F11.4)
     WRITE(IOUT, 8314) (WRIT(KX, 10), KX=1, 10)
8314 FORMAT(1H ,2X,14HRADIATOR (AVG),1X,10F11.4)
     WRITE(IOUT, 8315) (WRIT(KX, 11), KX=1, 10)
8315 FORMAT(1H ,2X,14HABSORBER (AVG),1X,10F11.4)
8302 IF(LONG)2019,2019,2008
2008 WRITE(10UT, 2009)
2009 FORMAT(1H1,52X,12HTEMPERATURES//)
     WRITE (IOUT, 2011)
2011 FORMAT (3X,4HNODE)
     WRITE(IOUT, 2012)
2012 FORMAT (3X,6HNUMBER,6X,1H0,9X,1H1,9X,1H2,9X,1H3,9X,1H4,9X,1H5,9X,1H
    16,9X,1H7,9X,1H8,9X,1H9)
     L=1
     DO 2050 I=2, IMAXP
     TMPTR(L) = TTE(I)
2050 L=L+1
      IF(LBNEW-1)7600,7600,7601
     JJZ=LBNEW/2
      IF(JJZ-3)7602,7602,7603
7603 JJZ=3
7602 JJK=1
      LLR=NOSEG
      NONE = 0
7608 LLS=NOSEG+1+NONE
      DO 7604 JJY=1,JJZ
      LLS=(LLS-1-NONE)*2+1+NONE
      DO 7605 J=JJK, LLR
      LL=IB(J)
      LU=IE(J)
      DO 7606 I=LL,LU
      LXY=LLS-J +NONE
 7606 T(1,LXY )=T(1,J)
 7605 CONTINUE
 7604 LLR=(LLR-NONE) *2+NONE
      IF(JJK-1)7607,7607,7600
 7607 LLR=LB+NOSEG
      JJK=LB+1
      NONE=LB
```

GO TO 7608

```
7600 DO 2051 J=1,LB
     IA=IB(J)
     IC=IE(J)
     DO 2052 I=IA, IC
     TMPTR(L)=T(I,J)
2052 L=L+1
2051 CONTINUE
     TMPTR(L)=TC
     L=L+1
     LL=LB+1
     LU=2*LB
     DO 2053 J=LL,LU
     IA=IB(J)
     IC=IE(J)
     DO 2054 I=IA, IC
     TMPTR(L)=T(I,J)
2054 L=L+1
2053 CONTINUE
     TMPTR(L)=TR
     LMAX=L
     WRITE(IOUT, 2014) (TMPTR(L), L=1,9)
2014 FORMAT(5X,2H 0,13X,9F10.2)
     L=10
2016 WRITE(IOUT, 2015)L, TMPTR(L), TMPTR(L+1), TMPTR(L+2), TMPTR(L+3), TMPTR(
    1L+4),TMPTR(L+5),TMPTR(L+6),TMPTR(L+7),TMPTR(L+8),TMPTR(L+9)
2015 FORMAT(17,3X,10F10.2)
     L=L+10
     IF(L-LMAX)2016,2016,2019
2019 CONTINUE
     IF(JFLAG)7018,7018,7019
7019 RETURN
7018 GO TO 366
 802 CONTINUE
      TERM4 = 2. * XKTE(IMAXP)*(U-UO)*(V-VO)/DELX
     TERM5 = .0
     TERM7 = .0
     DO 300 J=1,NOSEG
     I = IB(J)
     TERM5 = XK(I,J)*CONDI(I,J)*T(I,J)
                                          +TERM5
 300 TERM7 = XK(I,J) * CONDI(I,J)
                                 +TERM7
     TERM5=TERM5*WJZ
     TERM7=TERM7*WJZ
     Q = CCR*CURRNT**2-ALPHA(IMAXP)*CURRNT*TC+TERMC*ALPHAC*(U-UO)*(V-
    1VO)+TERM3*F2C*ALPHAC*(U-UO)*(V-VO)+TERM2*F1C*(U-UO)*(V-VO)*EPSC
    2-SIGMA*EPSC*TC**4*(U-U0)*(V-V0)
                                         +Q02
     TCP=TC
6016 TPRE(1)=TCP
6015 CONTINUE
     TC=(Q+ TERM4*TTE(IMAXP)+ TERM5)/(TERM4 + TERM7)
     TC = TCP + CFACT *(TC -TCP)
     DTMAX=ABS(TC-TCP)
     TERM4 = 2.*XKTE(2)*(U-U0)*(V-V0)/DELX
     TERM5 = .0
     TERM7 = .0
                                   *CURRNT*TR +TERMR*ALPHAR*(U-U0)*(V-V0)
     Q=RCR*CURRNT**2 +ALPHA(2)
    1 +TERM3*F2R*ALPHAR*(U-UO)*(V-VO)+TERM2*F1R*(U-UO)*(V-VO)*EPSR
    2 -SIGMA*TR**4*(U-U0)*(V-V0) *EPSR
                                          +Q02
     LL =LB +1
     LU≈LB+NOSEG
     DO 310 J=LL,LU
      I=IB(J)/ : :: ::::
```

```
TERM5=XK(I,J)*CONDI(I,J)*T(I,J)
                                          +TERM5
 310 TERM7=XK(I,J)*CONDI(I,J)
                                  +TERM7
     TERM5=TERM5*WJZ
     TERM7=TERM7*WJZ
     TRP=TR
6018 TPRE(2)=TRP
6017 CONTINUE
     TR = (Q +TERM4*TTE(2) +TERM5)/(TERM4 + TERM7)
     TR = TRP + CFACT*(TR-TRP)
     DTMAXP= ABS(TR-TRP)
     IF(DTMAXP-DTMAX)311,311,312
 312 DTMAX = DTMAXP
 311 CONTINUE
     TCP4=.5*(TAVC4+TAVR4)
     LI=2
     Q02=0.
     DO 320 I=2, IMAXP
     XKB = .5 * (XKTE(I) + XKTE(I-1))
     XKT=.5*(XKTE(I)+XKTE(I+1))
     L I = L I + 1
     TPR=TTE(I)
6020 TPRE(LI)=TPR
     IF(I-2)321,321,322
 321 \text{ TTE}(I-1) = TRP
     XKB=2.*XKTE(I)
     ALPHA(I-1)=ALPHA(2)
 322 IF(I-IMAXP)324,323,323
 323 TTE(I+1)=TCP
     XKT=2.*XKTE(I)
     ALPHA(I+1) = ALPHA(IMAXP)
 324 TI4= TTE(I)*TTE(I)*TTE(I)*TTE(I)
     QO1=-SIGMA*EPSI(I)*2.*(U-UO+V-VO)*DELX*(T14-TCP4)
     Q=+CURRNT**2*RESIST(I)*DELX/((U-U0)*(V-V0))
     2-CURRNT*TTE(I)*(ALPHA(I)-ALPHA(I-1))
                                               +001
      TTE(I)=(1./(XKB+XKT))*(Q*DELX/((U-UO)*(V-VO))+
     1TPRE(LI-1)*XKB+TTE(I+1)*XKT)
      TTE(I) = TPR +CFACT*(TTE(I)-TPR)
      DTMAXP = ABS(TTE(I) - TPR)
      IF (DTMAXP-DTMAX) 320, 320, 326
  326 DTMAX = DTMAXP
  320 Q02=Q02-Q01
      Q02=Q02/2.
      LIP=LI
      DO 7001 J=1, NOSEG
      IL=IB(J)
      IU=IE(J)
      DO 7002 I=IL, IU
      LI=LI+1
 7002 TPRE(LI)=T(I,J)
 7001 CONTINUE
      JL=LB+1
      JU=NOSEG+LB
      DO 7003 J=JL,JU
      IL=IB(J)
      IU=IE(J)
      DO 7004 I=IL, IU
      LI=LI+1
 7004 TPRE(LI)=T(I,J)
 7003 CONTINUE
      LI=LIP
      LBJ=NOSEG
```

```
IC=1
                                                                          CR SS
4071 IF(IC-1)331,330,331
 331 J=LB +1
     GO TO 332
 330 J=1
 332 IF(J-LBJ)333,334,333
 334 IF(IC-1)335,336,335
 333 JF=J+1
    GO TO 337
 336 JF=1
     GO TO 337
 335 JF=LB +1
 337 IF(J-1)339,338,339
 339 IF(J-LB -1)340,338,340
 338 JB=LBJ
     GO TO 341
 340 JB=J-1
 341 IL=IB(J)
     IU=IE(J)
     DO 1031 I=IL, IU
     IF(IC-1)342,343,342
 342 F3=1./(1./EPSR2(I,J) +1./EPSAC -1.)
     F1 = F1R
     F2= F2R
     TEPL=TPRE(2)
     TERM1 = TERMR
     EPSP=EPSR1(I,J)
     TAV4 = TAVC4
     GO TO 344
 343 F3=1./(1./EPSC2(I.J) +1./EPSAR -1.)
     F1 = F1C
     F2 = F2C
     TEPL=TPRE(1)
     TERM1 = TERMC
     TAV4
          =TAVR4
     EPSP=EPSC1(I,J)
      Q=TERM1*A(I,J)*ALPH(I,J) +TERM2*A(I,J)*F1*EPSP
                                                          +TERM3*A(I,J) *
    1F2*ALPH(I,J) -SIGMA *A(I,J)*EPSP
                                          *T4(I,J)-SIGMA*A(I,J)*F3
    2*(T4(I,J)-TAV4)
     LI=LI+1
     LIP=LI-(IE(J-1)-IB(J)+1)
     IF(LBJ-LB)6031,6031,6032
6031 LIPP=LI+LB-1+IE(1)-IB(LB)
     LLL=2
     LLU=LB-1
     DO 6033 JN=LLL, LLU
6033 LIPP=LIPP+IE(JN)-IB(JN)
     GO TO 6035
6032 LXY=2*LB
     LZZ=LB+1
     LIPP=LI+LB-1+IE(LZZ)-IB(LXY)
     LLL=LB+2
     LLU=2*LB-1
     DO 6034 JN=LLL,LLU
6034 LIPP=LIPP+IE(JN)-IB(JN)
6035 CONTINUE
     IF(I-IB(J))345,346,345
 346 TERMO(1-1,J) = - CONDI(1,J)*TEPL
     GO TO 5071
 345 TERMO(1-1,J)=-CONDI(1,J)*TPRE(LI-1)
5071 IF(J-1)347,348,347,4014-144111401-24
```

```
347 IF(J-LB -1)349,348,349
 348 TERMF(I,JB) = -CONDB(I,J)*TPRE(LIPP)
     TP(I) = T(I,J)
     GO TO 5070
 349 TERMF(I,JB)=-CONDB(I,J)*TPRE(LIP)
5070 TERMO(I,J) = -CONDI(I+1,J)*T(I+1,J)
     IF(J-LBJ)350,351,350
 351 TERMF(I,J) = -CONDB(I,JF)*TP(I)
     GO TO 2070
350 TERMF(I,J) = -CONDB(I,JF)*T(I,JF)
2070 TPR = T(I,J)
6022 TPRE(LI)=TPR
     COND=CONDI(I+1,J)+CONDB(I,JF)
    I+CONDI(I,J)+CONDB(I,J)
     T(I,J)=Q/(XK(I,J)*COND)+(-TERMO(I,J)-TERMF(I,J)
    1-TERMO(I-1,J)-TERMF(I,JB ))/COND
     T(I,J) = TPR + CFACT*(T(I,J) - TPR)
     DTMAXP = ABS(T(I,J) - TPR)
     IF(DTMAXP-DTMAX)1031,1031,353
 353 DTMAX = DTMAXP
1031 CONTINUE
1032 IF(J-LBJ)1033,352,352
1033 J=J+1
     GO TO 332
 352 IF(IC-1)2061,355,2061
 355 IC=0
     LBJ=NOSEG+LB
     GO TO 4071
2061 IF(DTMAX-EPST)367,367,6011
6011 IF(NIT-JCNT)7014,7014,7013
7013 CFACT=0.7
     TIME = . 0
     GO TO 7015
7014 CFACT=CFACT/DTMAX*TIMF*.9
7015 IF(DTMAX-TIMF)2074,2074,7042 '
2074 JZ=MOD(NIT, NL )
     IF(JZ)2076,2075,2076
2075 LONG=1
     GO TO 2001
2076 JY=MOD(NIT,NS )
     IF(JY)366,2078,366
2078 LONG=0
     GO TO 2001
     END
```

```
SIBFTC CALCT
               DECK, XR7
      SUBROUTINE CALCT(XK, CAP, EPSC1, EPSC2, EPSR1, EPSR2, ALPH, T, A, T4,
     1CONDI, CONDB, TERMF, TERMO, IX, L2, L22)
      COMMON Z
      DIMENSION Z(20000), XK(IX, L2), XKTE( 100 ), CAP(IX, L2), CAPTE( 100 ),
     1ALPHA(100), RESIST(100), EPSC1(IX , L22), EPSC2(IX , L22), EPSR1(IX , L22
     2) > EPSR2(IX > L22) + ALPH(IX + L2) + EPSI(100) + T(IX + L2) + TTE(100) + A(IX + L2) +
     3T4(IX,L2),CONDI(IX,L2),CONDB(IX,L2),TERMF(IX,L2),TERMO(IX,L2),
     4TP(100), IB(100), IE(100), ZA(200), TMPTR(1000), TPRE(1000),
     5WRIT(10,12) ,MATTE(15)
      EQUIVALENCE (Z(2), IOUT), (Z(5200), LB), (Z(11), LERR),
     1(Z(11716), XKTE(1)), (Z(5916), EPSI(1)), (Z(6016), TTE(1)),
     2(Z(11816), CAPTE(1)), (Z(5716), ALPHA(1)), (Z(5816), RESIST(1)),
     3(Z(17316), TP(1)), (Z(4414), TMACH), (Z(3246), WRIT(1)),
     4(ZA(54),XMAT), (Z(4415),MATC),(Z(4416),MATR)
      EQUIVALENCE (Z (6116), IB(1)), (Z (6216), IE(1)),
     1(Z(627),ZA(1)),(ZA(4),UO),(ZA(5),VO),(ZA(6),U),(ZA(7),V),
     2(Z (4356), SOLC), (Z (4357), ALBE), (Z (4358), SIGMA),
     3(Z (4400), RE), (Z(5208), IMAXP), (Z ( 626), TPLC),
     4(Z(5467), TPLAN), (Z(5466), F1C), (Z(5465), F1R), (Z(5464), F2C),
     5(Z(5463),F2R),(Z(5468),DELTA),(Z(5206),TC),(Z(5207),TR),
     6(Z(5462), ALPHAC), (Z(5461), EPSC), (Z(5469), TCP), (Z(5460), CAPC),
     7(Z(5459),DELTMP),(Z(5470),TRP),(Z(5458),F3),(Z(5457),F1),
     8(Z(5456),F2),(Z(4411),EPST),(Z(4402),TIMAX),(Z(4412), NL),
     9(Z(4413), NS),(Z(4419),CFACT),(Z(5455),NIT),(Z(5454),NITMAX)
      EQUIVALENCE
                                    (Z(5452), TAVC4), (Z(5451), EPSAR),
     1(Z(5450),TAVR4),(Z(5449),EPSAC),(Z(5448),RI ),(Z(5447),E),
     2(Z(5446), VOLT), (Z(5445), CURRNT), (Z(5444), POWR), (Z(4410), ISS),
     3(Z(5442),TI4),(Z(5441),TCP4),(Z(5440),CCR),(Z(5439),RCR),
     4(Z(5438),TIME),(Z(5437),TIML),(Z(5436),TIMS),(Z(4406),TIMPL),
     5(Z(4407), TIMPS), (Z(4405), TIMF), (Z(5480), TERM3),
     6(Z(5435),V1),(Z(5434),V2),(Z(5433),V3),(Z(5432),V4),
     7(Z(5431),V5),(Z(5430),V6),(Z(5429),MAY),(Z(5428),J),
     8(Z(5427),TXX),(Z(5426),I),(Z(5425),JL),(Z(5424),JU),
     9(ZA(75), TPLR)
      EQUIVALENCE (Z(5423), TERM2), (Z(5422), TERM6), (Z(5421), TERMR),
     1(Z(5420),EA),(Z(5419),ATOT),(Z(5418),AXT),(Z(5417),JJ),
     2(Z(5416), II), (Z(5478), LP),
                                                   (Z(5414), TERM4),
     3(Z(5413),TERM5),(Z(5412),TERM7),(Z(5411),Q),(Z(5410),TERM1),
     4(Z(5409), LBJ), (Z(5408), IC), (Z(5407), JF), (Z(5473), TEPL),
     5(Z(5476), EPSP), (Z(5406), LONG), (Z(5474), NLINE), (Z(14616), TMPTR(1))
     6, (Z(5405), LL), (Z(5404), LU), (Z(5403), IA),
     7(Z(5472),LMAX),(Z(5471),TPR),(Z(5401),JZ),(Z(5400),JY),
     8 (Z(4403), TMIN), (Z(4404), TMX), (Z(4401), SEGM),
     9(Z(5211),DELX),(ZA(166),XIMAX),(Z(18000),TPRE(1))
      DO 310 IN=1,10
      DO 310 JN=1,12
  310 WRIT(IN, JN) =0.
      Q02=0.
      DELTM=10.
      NITMAX=TMX
      TMULT=TIMF
      TIME=0.
      TDEC=TMULT/100.
      SLB=LB
      LBNEW=SLB/SEGM+.01
      JJZ=1
      DO 7501 I=1,4
      IF(LBNEW-JJZ)7501,7502,7501
 7501 JJZ=2*JJZ
```

LBNEW=1 ...

```
7502 WJZ=LBNEW
     NOSEG=LB/LBNEW
     IF(NOSEG-LB)7503,7504,7504
7503 IL=IB(1)
     IU=IE(1)
     DO 7505 I=IL, IU
     CONDB(I,1)=0.
7505 CONDB(I,LB+1)=0.
     IL=IB(NOSEG+1)
     J=LB+NOSEG+1
     IU=IE(J)
     DO 7506 I=IL, IU
     CONDB(I,NOSEG+1)=0.
7506 CONDB(I,J)=0.
7504 CONTINUE
     TIMF=0.
     JFLAG=0
     NLINE=0
     JCNT=TMACH
     IMAX=XIMAX
     KX=0
     NIT=0
     DELT=1.0
  25 TERM3=SOLC*ALBE
     TIMS = TIMPS
                                                                               PRNT
     TIML = TIMPL
 607 NIT=NIT+1
     IF(NIT-100)7010,7011,7011
7010 TIMF=TIMF+TDEC
7011 JTE=XMAT
     JCOL=MATC
     JRAD=MATR
     JCCON=ZA(79)+1.E-4
     JRCON=ZA(119)+1.E-4
     CALL PROP(TC, V1, CAPC, ALPHAC, EPSC, EPS2C, V6, JCOL)
     CALL PROP(TR, V1, CAPR, ALPHAR, EPSR, EPS2R, V6, JRAD)
     DO 600 J=1.NOSEG
      I = IB(J)
 603 TXX = T(I,J)
     CALL PROP ( TXX, V1, V2, V3, V4, V5, V6, JCOL)
     XK(I,J) = V1
     CAP(I,J)=V2
     ALPH(I,J)=V3
     EPSC1(I,J)=V4
     EPSC2(I_9J)=V5
     IF(I-IE(J))601,600,600
 601 I = I + 1
     GO TO 603
 600 CONTINUE
     JL= LB+1
     JU=NOSEG+LB
     DO 602 J=JL,JU
     I = IB(J)
 605 TXX = T(I,J)
     CALL PROP(TXX,V1,V2,V3,V4,V5,V6,JRAD)
     XK(I_{\bullet}J) = V1
     CAP(I_9J)=V2
     ALPH(I,J)=V3
     EPSR1(I_9J)=V4
     EPSR2(I_9J)=V5
     IF(I-IE(J))604,602,602
```

```
604 I = I + 1
    GO TO 605
602 CONTINUE
    DO 606 I=2, IMAXP
    TXX=TTE(I)
    CALL PROP(TXX,V1,V2,V3,V4,V5,V6,JTE)
    ALPHA(I)=V1
    XKTE(I) =V2
    RESIST(I)=V3
    CAPTE(I
              )=V4
    EPSI(I)
               =V5
606 CONTINUE
    MAY=17
    CALL PROP(TIME, TPLAN, F1C, F1R, F2C, F2R, DELTA, MAY)
    DELTA=DELTA/57.296
    CALL PROP(TC, V1, V2, CCR, V4, V5, V6, JCCON)
    CALL PROP(TR, V1, V2, RCR, V4, V5, V6, JRCON)
    TERM2=SIGMA*TPLAN*TPLAN*TPLAN*TPLAN
    IF(DELTA-1.5708)810,810,811
810 TERMC=SOLC*COS(DELTA)
    TERMR= • 0
    GOTO 812
811 TERMR=SOLC*COS(DELTA)
    TERMC= • 0
812 CONTINUE
 21 EA= . 0
    EPSAR= . 0
    TAVR4= • 0
    ATOT = 0
    AXT = 0
    JJ=LB+1
 11 II=IB(JJ)
 12 ATOT=ATOT+A(II,JJ)
     T4(II)T*(LL, II)T*(LL, II)T*(LL, II)T=(LL, II)T+
    AXT=AXT + A(II,JJ)*T4(II,JJ)
     EA=EA+A(II,JJ)*EPSR2(II,JJ)
     IF(II-IE(JJ))101,100,100
101 11=11+1
     GO TO 12
100 LP=LB+NOSEG
     IF(JJ-LP)103,102,102
103 JJ=JJ+1
     GO TO 11
102 TAVR4=AXT/ATOT
     EPSAR=EA/ATOT
     TAVR=SQRT(TAVR4)
     TAVR=SQRT(TAVR)
  20 EA= .0
     TAVC4= . 0
     ATOT= 00
     AXT = 0
     EPSAC= . 0
     JJ=1
  13 II=IB(JJ)
  14 ATOT=ATOT+A(II,JJ)
     T4(II, JJ) = T(II, JJ) T*((II, JJ) * T(II, JJ) * T(II, JJ)
     (UU,II) + T*(UU,II) A + TXA=TXA
     EA=EA+A(II,JJ)*EPSC2(II,JJ)
     IF(II-IE(JJ))108,109,109
 108 11=11+1
 C= GO!TO:14
```

```
109 IF(JJ-NOSEG)110,111,111
110 JJ=JJ+1
     GO TO 13
111 TAVC4=AXT/ATOT
     EPSAC=EA/ATOT
     TAVC=SQRT(TAVC4)
     TAVC=SQRT(TAVC)
                       ALPHA(2)
     E = (TTE(2) - TR) *
     DO 380 I=3, IMAXP
380 E=E+(TTE(I)-TTE(I-1))*.5*(ALPHA(I)+ALPHA(I-1))
     E=E+(TC-TTE(IMAXP))*
                                     ALPHA (IMAXP)
     DO 381 I=3, IMAXP
381 RI=RI+DELX*.5*(RESIST(I)+RESIST(I-1))
     RI=1./((U-UO)*(V-VO))*(RI)+RCR+CCR
     CURRNT=E/(RI+RE)
     VOLT=CURRNT*RE
     POWR=VOLT*CURRNT
801 CONTINUE
     DELTS=DELT
     TERM6=DELT/(TPLC*(U-UO)*(V-VO))
     TERM4=(XKTE(IMAXP)*(U-UO)*(V-VO)*(TTE(IMAXP)-TC) )*2./DELX
     TERM5= • 0
     DO 226 J=1, NOSEG
     I = IB(J)
     TERM5= TERM5 +XK(I,J)*CONDI(I,J)*(T(I,J)-TC)
226 CONTINUE
     TERM5=TERM5*WJZ
     ALPC=ALPHA(IMAXP)
     Q = CCR*CURRNT**2-ABS(ALPC )*CURRNT*TC+TERMC*ALPHAC*(U-U0)*(V-
    1VO) +TERM3*F2C*ALPHAC*(U-UO)*(V-VO)+TERM2*F1C*(U-UO)*(V-VO)*EPSC
    2-SIGMA*EPSC*TC**4*(U-U0)*(V-V0) +Q02
     TPRE(1) = TC
     TC= TC +TERM6/CAPC*(Q +TERM4 +TERM5)
     IF(ABS(TC)-1.0E+05)5025,367,367
5025 CONTINUE
     DTMAX = ABS(TC-TPRE(1))
     TERM6=DELT/(TPLR*(U-UO)*(V-VO))
     TERM4= 2.*XKTE(2)*(U-UO)*(V-VO)*(TTE(2)-TR)
                                                     /DELX
     TERM5= . 0
     LL=LB+1
     LU=LB+NOSEG
     DO 251 J=LL,LU
     I = IB(J)
 251 TERM5=TERM5 +XK(I,J)*CONDI(I,J)*(T(I,J)-TR)
     TERM5=TERM5*WJZ
     ALPR=ALPHA(2)
     Q = RCR *CURRNT**2 +ABS(ALPR )*CURRNT*TR+TERMR*ALPHAR*(U-U0)*(V
    1-VO) +TERM3*F2R*ALPHAR*(U-UO)*(V-VO)+TERM2*F1R*(U-UO)*(V-VO)*EPSR
    2-SIGMA*EPSR*TR**4*(U-U0)*(V-V0) +Q02
     TPRE(2) = TR
     TR= TR+ TERM6/CAPR*(Q+TERM4+TERM5)
     DTMAXP=ABS(TR-TPRE(2))
     IF (DTMAXP-DTMAX) 5005,5005,5006
5006 DTMAX=DTMAXP
5005 CONTINUE
     TCP4=.5*(TAVC4+TAVR4)
     LI=2
     DO 7000 I=2, IMAXP
     LI = LI + I
7000 TPRE(LI)=TTE(I)
```

```
LI=2
     Q02=0.
     DO 200 I=2.IMAXP
     QQ=1.
     QR=1.
     QY=2.
     LI=LI+1
     TXB=TPRE(LI-1)
     TXA=TPRE(LI+1)
     IF(I-2)201,201,202
201 ALPHA(I-1)=ALPHA(2)
     QQ=2
     QY=3.
202 IF (I-IMAXP) 204, 203, 203
203 TXA
             =TPRE(1)
     QR=2.
     QY=3.
     ALPHA(I+1)=ALPHA(IMAXP)
204 TI4=TTE(I)*TTE(I)*TTE(I)
     QO1=-SIGMA*EPSI(I)*2.*(U-UO+V-VO)*DELX*(TI4-TCP4)
     Q=CURRNT**2*RESIST(I)*DELX/((U-UO)*(V-VO))
    2-CURRNT*TTE(I)*(ALPHA(I)-ALPHA(I-1)) +QO1
     RHS=-XKTE(I)*(U-UO)*(V-VO)/DELX*(-QQ*TXB-QR*TXA
    1+QY*TPRE(LI))+Q
     TTE(I)=TTE(I)+DELT/(CAPTE(I)*(U-UO)*(V-VO)*DELX)*RHS
5039 DTMAXP=ABS(TTE(I)-TPRE(LI))
     IF(DTMAXP-DTMAX)5007,5007,5008
5008 DTMAX=DTMAXP
5007 Q02=Q02-Q01
     Q02=Q02/2.
200 CONTINUE
     LBJ=NOSEG
  24 IC=1
  10 IF(IC-1)112,113,112
 112 J = LB + 1
     GO TO 4
 113 J=1
   4 IF(J-LBJ)115,114,115
 115 JF=J+1
     GO TO 116
 114 IF(IC-1)118,117,118
 118 JF=LB +1
     GO TO 116
 117 JF=1
 116 IF(J-1)120,121,120
 120 IF(J-LB -1)122,121,122
 121 JB=LBJ
     GO TO 2
 122 JB=J-1
   2 IL= IB(J)
     IU=IE(J)
     DO 1002 I=IL, IU
 129 IF(IC-1)131,130,131
 131 F3=1./(1./EPSR2(1,J)+1./EPSAC-1.)
     TEPL=TPRE(2)
     TERM1=TERMR
     F1=F1R
     F2=F2R
     EPSP=EPSR1(I,J)
     THPL =TPLR
     TAV4=TAVC4
```

```
GO TO 26
 130 F3=1./(1./EPSC2(I,J)+1./EPSAR-1.)
     TEPL=TPRE(1)
     TERM1=TERMC
     TAV4 = TAVR4
     F1=F1C
     F2=F2C
     EPSP=EPSC1(I,J)
     THPL =TPLC
  26 Q=TERM1*A(I,J)*ALPH(I,J) + ALPH(I,J) * TERM3*A(I,J)*F2 -SIGMA
    1*A(I,J)*EPSP *T4(I,J)-SIGMA*A(I,J)*F3*(T4(I,J)-TAV4)
    2+TERM2*A(I,J)*F1 *EPSP
     LI=LI+1
     TPRE(LI)=T(I,J)
     IF(I-Ib(J))141,140,141
140 TERMO(I-1,J)=-CONDI(I,J)*(T(I,J)-TEPL)
 141 IF(J-1)143,142,143
 143 IF(J-LB -1)821,142,821
 142 \text{ TERMF}(I,JB) = -CONDB(I,J)*(T(I,J)-T(I,JB))
     TP(I) = T(I,J)
 821 TERMO(I,J) = CONDI(I+1,J) * (T(I,J)-T(I+1,J))
     IF (J-LBJ) 145, 144, 145
 144 TERMF(I,J)=CONDB(I,JF)*(T(I,J)-TP(I))
     GO TO 2071
 145 TERMF(I,J) = CONDB(I,JF) * (T(I,J) - T(I,JF))
2071 T(I,J)=T(I,J)+ DELT/CAP(I,J)*(Q+XK(I,J)*(-TERMO(I,J)-TERMF(I,J)
    1+TERMO(I-1,J) + TERMF(I,JB)))/(A(I,J)*THPL)
5041 DTMAXP=ABS(TPRE(LI)-T(I,J))
     IF(DTMAXP-DTMAX)5009,5009,5010
5010 DTMAX=DTMAXP
5009 CONTINUE
1002 CONTINUE
1003 IF(J-LBJ)1004,147,147
1004 J = J + 1
     GO TO 4
 147 IF(IC-1)27,149,27
 149 IC=0
     LBJ=LB+NOSEG
     GO TO 10
  27 TIME=TIME+DELT
     GOTO 365
5013 CONTINUE
5043 IF(NIT-NITMAX)1006,367,367
1006 CONTINUE
     JZ=MOD(NIT, NL )
     IF(JZ)5030,362,5030
5030 JY=MOD(NIT,NS)
     IF(JY)5031,364,5031
5031 CONTINUE
     IF(TIME-TIME )361,361,362
 362 LONG=1
     NLINE=0
     TIML= TIML + TIMPL
     TIMS = TIMS + TIMPS
     GO TO 2001
 361 IF(TIME-TIMS)5002,5002,364
 364 LONG=0
     TIMS=TIMS + TIMPS
     GO TO 2001
 365 CONTINUE
     IF(DTMAX-TIMF)5014,5014,5012
```

```
5014 DELT=.9*TIMF/DTMAX*DELT
     GO TO 5013
5012 TIME=TIME-DELT
     DELT=DELTM*DELT
     TIME=TIME+DELT
7042 DELTM= . 9*TIMF/DTMAX
     TC=TPRE(1)+DELTM*(TC-TPRE(1))
     TR=TPRE(2) +DELTM*(TR-TPRE(2))
     LI=2
     DO 5019 I=2, IMAXP
     LI=LI+1
5019 TTE(I)=TPRE(LI) +DELTM*(TTE(I)-TPRE(LI))
     LL=1
     LU=NOSEG
     DO 5020 J= LL.LU
     IL=IB(J)
     IU=IE(J)
     DO 5021 I=IL, IU
     LI = LI + 1
5021 T(I,J)=TPRE(LI) +DELTM*(T(I,J)-TPRE(LI))
5020 CONTINUE
     LL=LB+1
     LU=LB+NOSEG
     DO 5022 J=LL,LU
     IL=IB(J)
     IU=IE(J)
     DO 5023 I=IL, IU
     LI=LI+1
5023 T(I,J)=TPRE(LI)
                       +DELTM*(T(I,J)-TPRE(LI))
5022 CONTINUE
     GO TO 5013
5002 IF(TIME-TIMAX)366,366,367
 366 IF (NIT - NITMAX)607,367,367
 367 CONTINUE
     JFLAG=1
     LONG=1
2001 QIC=0.
     QRC=0.
     QIR=0.
     QRR=0.
     QOC=0.
     QOR = 0 .
     QINC=TERMC*ALPHAC*(U-UO)*(V-VO)+TERM3*F2C*ALPHAC*(U-UO)*(V-VO)
    1+TERM2*F1C*(U-U0)*(V-V0)*EPSC
     QRAC=SIGMA*EPSC*TC**4*(U-UO)*(V-VO)
     QIN=QINC
7900 QOUT=QRAC+CAPC*(U-UO)*(V-VO)*TPLC*(TC-TPRE(1))/DELTS
7902 QINR=TERMR*ALPHAR*(U-UO)*(V-VO)+TERM3*F2R*ALPHAR*(U-UO)
    1*(V-VO)+TERM2*F1R*(U-UO)*(V-VO)*EPSR
     QRAR=SIGMA*EPSR*TR**4*(U-U0)*(V-V0)
     QIN=QIN+QINR
7903 QOUT=QOUT+QRAR+CAPR*(U-UO)*(V-VO)*TPLR*(TR-TPRE(2))/DELTS
7905 LI=2
     DO 7906 I=2, IMAXP
     LI = LI + 1
7906 CONTINUE
     DO 7909 J=1,NOSEG
     IL=IB(J)
     IU=IE(J)
     DO 7910 I=IL,IU
     LI=LIta : Lacian
```

```
QIC=QIC+TERMC*A(I,J)*ALPH(I,J)+TERM3*A(I,J)*F2C*ALPH(I,J)
    1+TERM2*A(I,J)*F1C*EPSC1(I,J)
     QX=SIGMA*A(I,J)*EPSC1(I,J)*T(I,J)**4
    QOC=QOC+QX+CAP(I,J)*A(I,J)*TPLC*(T(I,J)-TPRE(LI))/DELTS
     QRC=QRC+QX
7910 CONTINUE
7909 CONTINUE
     QIC=QIC*WJZ
     QRC=QRC*WJZ
     QOC=QOC*WJZ
     QIN=QIN+QIC
     QINC=QINC+QIC
     QRAC=QRAC+QRC
     QOUT=QOUT+QOC
     LL=LB+1
     LU=LB+NOSEG
     DO 7913 J=LL,LU
     IL=IB(J)
     IU=IE(J)
     DO 7914 I=IL, IU
     LI = LI + 1
     QIR=QIR+TERMR*A(I,J)*ALPH(I,J)+ALPH(I,J)*TERM3*A(I,J)*F2R
    1 +TERM2*A(I,J)*F1R*EPSR1(I,J)
     QY=SIGMA*A(I,J)*EPSR1(I,J)*T(I,J)**4
     QOR=QOR+QY+CAP(I,J)*A(I,J)*TPLR*(T(I,J)-TPRE(LI))/DELTS
     QRR=QRR+QY
7914 CONTINUE
7913 CONTINUE
     QOR=QOR*WJZ
     QRR = QRR * WJZ
     QIR=QIR*WJZ
     QIN=QIN+QIR
     QINR=QINR+QIR
     QRAR=QRAR+QRR
     QOUT=QOUT+QOR
     QAVG=.5*(QIN+QOUT+POWR)
                 (QIN-(QOUT+POWR))/QAVG
     ERROR=
     EFF=100.*(POWR/QINC)
     KX = KX + 1
8300 WRIT(KX,1)=TIME
     WRIT(KX,2)=DELT
     WRIT(KX,3)=NIT
     WRIT(KX,4)=POWR
     WRIT(KX,5)=CURRNT
      WRIT(KX,6)=ERROR
      WRIT(KX,7)=EFF
      WRIT(KX,8)=TC
     WRIT(KX,9)=TR
      WRIT(KX,10)=TAVR
     WRIT(KX,11)=TAVC
      IF(KX-10)8318,8301,8301
8318 IF (JFLAG) 8302, 8302, 8301
8301 WRITE(IOUT, 8303) (WRIT(KX, 1), KX=1, 10)
8303 FORMAT(1H0,1X,4HTIME,12X,10F11.4)
      WRITE(IOUT, 8305) (WRIT(KX, 2), KX=1, 10)
8305 FORMAT(1H ,1X,14HTIME INCREMENT,2X,10F11.6)
      WRITE(IOUT, 8306) (WRIT(KX, 3), KX=1, 10)
 8306 FORMAT(1H ,1X,13HITERATION NO.,3X,10F11.1)
      WRITE(IOUT, 8307) (WRIT(KX, 4), KX=1, 10)
 8307 FORMAT(1H ,1X,5HPOWER,11X,10F11.5)
      WRITE(IOUT,8308)(WRIT(KX,5),KX=1,10)
```

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8308 FORMAT(1H ,1X,7HCURRENT,9X,10F11.5)
     WRITE(IOUT, 8309) (WRIT(KX, 6), KX=1,10)
8309 FORMAT(1H ,1X,5HERROR,11X,10F11.6)
     WRITE(IOUT, 8310) (WRIT(KX, 7), KX=1, 10)
8310 FORMAT(1H ,1X,10HEFFICIENCY,6X,10F11.6)
     WRITE(IOUT,8312)
     WRITE(IOUT, 8311) (WRIT(KX, 8), KX=1, 10)
8312 FORMAT(1H ,1X,12HTEMPERATURES)
8311 FORMAT(1H , 2X, 12HHOT JUNCTION, 3X, 10F11.4)
     WRITE(IOUT, 8313) (WRIT(KX,9), KX=1,10)
     FORMAT(1H ,2X,13HCOLD JUNCTION,2X,10F11.4)
     WRITE(IOUT, 8314) (WRIT(KX, 10), KX=1, 10)
8314 FORMAT(1H ,2X,14HRADIATOR (AVG),1X,10F11.4)
     WRITE(IOUT, 8315) (WRIT(KX, 111, KX=1, 10)
8315 FORMAT(1H ,2X,14HABSORBER (AVG),1X,10F11,4)
     KX = 0
8302 IF(LONG)2019,2019,2008
2008 WRITE(IOUT, 2009)
2009 FORMAT(1H1,52X,12HTEMPERATURES//)
     WRITE(IOUT, 2011)
2011 FORMAT(3X,4HNODE)
     WRITE (IOUT, 2012)
2012 FORMAT(3X,6HNUMBER,6X,1H0,9X,1H1,9X,1H2,9X,1H3,9X,1H4,9X,1H5,9X,1H
    16,9X,1H7,9X,1H8,9X,1H9)
     L=1
     DO 2050 I=2, IMAXP
     TMPTR(L)=TTE(I)
2050 L=L+1
     IF(LBNEW-1)7600,7600,7601
7601
     JJZ=LBNEW/2
     IF(JJZ-3)7602,7602,7603
7603 JJZ=3
7602 JJK=1
     LLR=NOSEG
     NONE=0
7608 LLS=NOSEG+1+NONE
     DO 7604 JJY=1,JJZ
     LLS=(LLS-1-NONE)*2+1+NONE
     DO 7605 J=JJK, LLR
     LL=IB(J)
     LU=IE(J)
     DO 7606 I=LL,LU
     LXY=LLS-J +NONE
7606 T(I,LXY )=T(I,J)
7605 CONTINUE
7604 LLR=(LLR-NONE)*2+NONE
     IF(JJK-1)7607,7607,7600
7607 LLR=LB+NOSEG
     JJK=LB+1
     NONE = LB
     GO TO 7608
7600 DO 2051 J=1,LB
     IA=IB(J)
     IC=IE(J)
     DO 2052 I=IA,IC
     TMPTR(L)=T(I,J)
2052 L=L+1
2051 CONTINUE
     TMPTR(L)=TC
     L=L+1
     LL=LB+1
```

```
LU=2*LB
     DO 2053 J=LL LU
     IA=IB(J)
     IC=IE(J)
     DO 2054 I=IA, IC
     TMPTR(L)=T(I,J)
2054 L=L+1
2053 CONTINUE
     TMPTR(L)=TR
     LMAX=L
     WRITE(IOUT, 2014) (TMPTR(L), L=1,9)
2014 FORMAT(5X,2H 0,13X,9F10.2)
     L=10
2016 WRITE(IOUT, 2015)L, TMPTR(L), TMPTR(L+1), TMPTR(L+2), TMPTR(L+3), TMPTR(
    1L+4),TMPTR(L+5),TMPTR(L+6),TMPTR(L+7),TMPTR(L+8),TMPTR(L+9)
2015 FORMAT(17,3X,10F10.2)
     L=L+10
     IF(L-LMAX)2016,2016,2019
2019 CONTINUE
     IF(JFLAG) 7018, 7018, 7019
7019 RETURN
7018 GO TO 5002
     END
```